RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

What does the waste say about the medieval town of Banská Bystrica (Central Slovakia) and its environment

Co vypovídá odpad o středověké Banské Bystrici (střední Slovensko) a jejím přírodním prostředí

Martin Miňo – Barbora Styková – Ivan Jarolímek – Jozef Šibík – Mária Šibíková – Mojmír Choma – Katarína Šimunková – Michaela Látková – Ivo Světlík – Kateřina Pachnerová Brabcová – Markéta Petrová – Peter Ďurica – Peter Barta – Pavol Midula – Janka Ševčíková

The historical town hall of Banská Bystrica was rebuilt in the second half of the 16th century from a medieval town mansion that had traditionally been owned by the town's high-ranking citizens. As the building was an important structure, there is an extraordinary record of written sources depicting its history. However, there is almost no information before the year 1500 due to the fire that destroyed the town archives. Just as the fire obliterated the written record, modern construction activities severely damaged the archaeological record. The archaeological survey at the historical town hall of Banská Bystrica conducted between 2008 and 2009 could be considered a prime example of a rescue event. The small assemblage of artefacts dated shortly before and after the great fire was complemented by animal bones, water-preserved wooden planks, and archaeobotanical material. These finds underwent dendrochronological and radiocarbon dating, providing clues for assessing settlement continuity from the pre-colonisation period. By applying an interdisciplinary approach, which included the analysis of pottery, chemical analysis, DNA sampling, archaeobotanical and archaeozoological analysis, it became possible to reconstruct certain aspects of everyday life as well as the environment in the town and its surroundings.

absolute dating – interdisciplinary research – archaeobotany – environment – geochemistry – Middle Ages – reverse 3D modelling

Historická radnice v Banské Bystrici byla přestavěna v druhé polovině 16. století ze středověkého městského sídla, které tradičně patřilo vysoce postaveným osobám ve městě. Protože se jednalo o významnou stavbu, dochovaly se k ní mimořádné písemné prameny zachycující její historii. Pro období před rokem 1500 se však nedochovaly téměř žádné informace kvůli požáru, který zničil městský archiv. Stejně jako požár smazal písemné záznamy, novodobá stavební činnost vážně poškodila archeologické záznamy. Archeologický průzkum historické radnice v Banské Bystrici, který proběhl v letech 2008 a 2009, lze považovat za ukázkový příklad záchranné akce. Skrovný soubor artefaktů, datovaný krátce před a po velkém požáru, doplnily zvířecí kosti, dřevěná prkna zachovaná v zamokřeném prostředí a archeobotanický materiál. Tyto nálezy byly podrobeny dendrochronologickému a radiokarbonovému datování, což poskytlo vodítka pro posouzení kontinuity osídlení z předkolonizačního období. Uplatněním interdisciplinárního přístupu, který zahrnoval analýzu keramiky, chemickou analýzu, odběr vzorků DNA, archeobotanickou a archeozoologickou analýzu, bylo možné rekonstruovat některé aspekty každodenního života i prostředí ve městě a jeho okolí.

absolutní datování – interdisciplinární výzkum – archeobotanika – přírodní prostředí – geochemie – středověk – reverzní 3D modelování

https://doi.org/10.35686/AR.2025.251

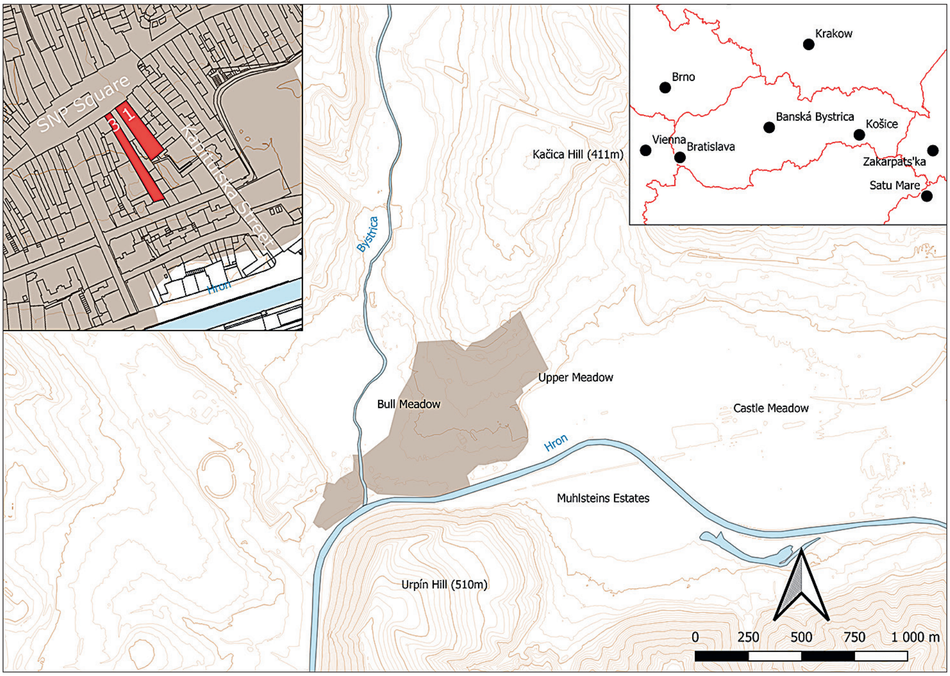

Fig. 1. Localisation of the surveyed site.

Introduction

The town of Banská Bystrica was founded before the year 1255 AD, when the town charter, the first known written source concerning the town, was issued. The town's name is mentioned as *nova villa bystriciensis*, which is usually interpreted as proof of an older medieval settlement at the site (e.g. *Baláž 2002*, 7). This is partially supported by archaeological evidence for settlement phases dated to the 9th century AD (*Mácelová 2013*, 74–75). The medieval town, which was part of the Hungarian Kingdom and now of Central Slovakia, was located on an outcrop of Kačica Hill pointing into the confluence of the Bystrica, a mountain river, and the region's major water course, the Hron River (*Fig. 1*). The earliest known representation of the urbanistic structure of the town is depicted in the 16th-century Ferrari map produced while the town walls were being planned (*Sura 1982*, 12–13).

In this paper, we focus on a plot in the older southeastern part of the town situated very close to the street leading to the Hron River crossing, where the medieval town hall was built in the second half of the 16th century at the site of a medieval town mansion. This study aims to present and interpret the comprehensive results of the excavation campaign and the analyses performed, which contribute to an understanding of town development in Central Europe.

According to previous research in the field of the history of architecture, the town hall building was originally a town manor that evolved from merging two separate three-room houses into a single house of the thoroughfare type (*Fig. 2*; *Sura 1982*, 110–113; *Staníková 1990*; *Sura et al. 1996*). This evolutionary scheme is traditionally applied to most of

Fig. 2. Evaluation of the finds on the plot of Square SNP 4: A – Town hall development model from two different medieval houses; B – analysis of archaeologically or historically dated features.

the buildings in the medieval town centre (*Sura 1982*). Later archaeological and historical building surveys elaborate further on this model. They point to an earlier phase most likely based on a timber frame construction combined with wattle and daub walls, while only the storage room was constructed in masonry (*Šimkovic – Žuffová 2021*, 116–117). Destruction layers of wattle and daub walls were documented, for example, at Horná Street 2–4 by *Zachar* and *Mácelová* (*2008*) and *Kvietok* (*2016*), and this phase seems to be documented on the plot of the later town hall as well. A burned clay layer was found in the cellar (*Sura et al. 1996*, fig. 7), which lies under the base of the oldest recorded masonry walls. A similar layer was recorded under the base of one of the pillars supporting the backyard façade (*Fig. 3*) and spread across the plain of the backyard (*Miňo et al. 2008*, layer K006, fig. 28).

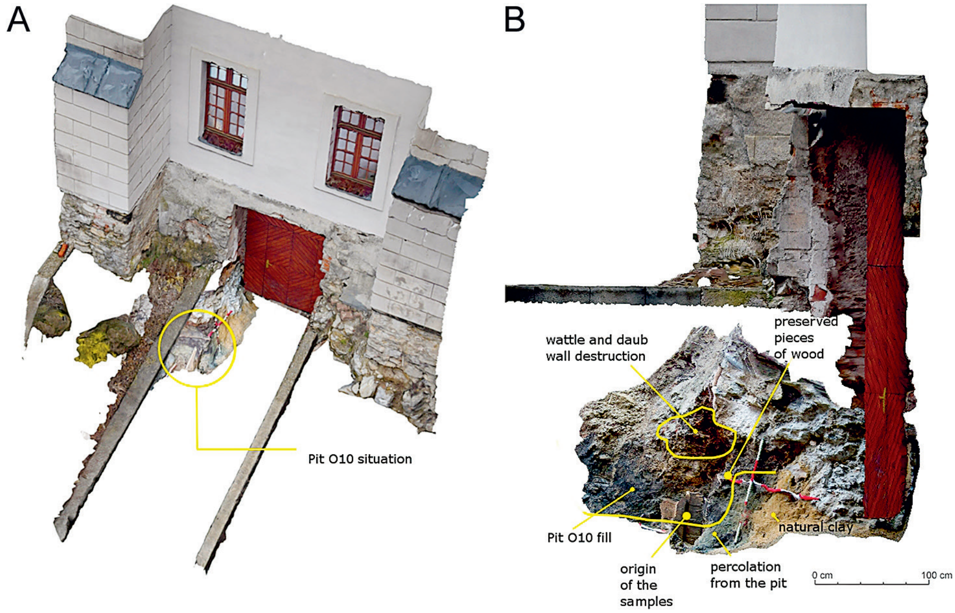

Fig. 3. Cess pit O10: K006 – wattle and daub building destruction; O10 – sampled sediment; R52 – dendrochronologically dated plank; percolation – substratum clay with marks of organic matter that has percolated from the cesspit (3D model by P. Ďurica, photo by M. Miňo).

Due to the great fire of Banská Bystrica in 1500, which destroyed most of the town's archives, we know more about the owners than the house itself. During this phase, the house was owned by Stephan Jung, the owner of a copper mine and town mayor in 1450 and 1454. After his two sons died suddenly in 1465, he sold the house to the Buda citizens Johan Ernst and Veit Mühlstein for 6,200 ducats (*Staníková 1990*; *Sura 1982*; *Sura et al. 1996*). Veit Mühlstein came to town, probably with King Matthias Corvinus. He served as the vice-count and later as the count of Zvolen County. He also held the office of the count of the mining chamber in Kremnica. He was the owner of a green paint mine in Špania Dolina – Piesky (Sandberg; see *Lacko 2024*) and was also elected mayor of the town. He founded one of the chapels in the parish church and one of the towers in the walls of the town castle. During his ownership of the house, the last medieval building phase, prompted by the great fire of 1500, began. However, Mühlstein died in 1501, so it is highly probable that the building activities were not completed and were continued by his heirs. In this phase, the front part of the house was rebuilt in stone. The two-story house had a three-room layout. A vaulted cellar was built under parts of the house (*Staníková 1990*; *Sura et al. 1996*). The interiors were heated with tiled stoves featuring figural motives, likely made in a famous workshop in Banská Bystrica (*Mácelová 2005*). There seems to be more than one Late Gothic building phase, as is evident from the historical building survey. This might be a result of the inheritance following Mühlstein's death. Though the two different surveys were conducted only a few years apart, they produced different results. The ground plan of the house provided in this paper (*Fig. 2*) is a combination of the results of both surveys that did not contradict each other (*Staníková 1990*; *Sura et al. 1996*). However, it should be noted that the dating of several constructions attributed in both surveys to Gothic phases was later than the 16th century according to the archaeological stratigraphy (mainly the yard wing of the house; compare to *Miňo et al. 2008*). After Veit Mühlstein passed away, the house was inherited by his daughter-in-law's third husband, Henrich Kindlinger, who was the last private owner of the property (*Staníková 1990*; *Sura 1982*; *Sura et al. 1996*).

After his death in 1539, Emperor Ferdinand I granted the property to the municipality, which used it for the town hall. The town rebuilt the house in 1546, when a vault was constructed on the ground floor (perhaps over the original yard between the two medieval houses), the roof was changed, a new staircase was built in the back part of the building, the wastewater was directed into a stone outlet, the entire building was plastered, and the town bakery was built in the yard. The construction was supervised by Master Linhard. The change to the roof might be linked to the Renaissance-style attic that was added to the main building in the 16th century.

The first record referring to the town hall's internal organisation is from the year 1555. Only a single room on the second floor was used for this purpose, while other rooms were rented out. The records indicate that in addition to the main masonry, there were other structures on the property: the house at the well, an old brewery, a barn converted into brick storage, and a garden stretching down to the riverside. The 'house at the well' would most likely correspond to some or all of the walls 1, 2, and 8 documented in the yard near the well (O6), which were dated to the 16th century by stratigraphy (*Fig. 2*).

In 1566, the building activities were led by Master Pankratz, who built a vault over the cellar, some interior walls and a wall around the property. Since 1570, the town scribe lived in the town hall, and the second scribe also moved there in 1579. Beginning in 1586, the town-watch commander resided here, and in 1591 and 1662, there are records of an organist living in the building. The first reconstruction of the main façade was carried out by Jacob II di Pauli in 1632. He painted it an aquamarine colour, which he created by mixing indigo with the local copper-based green paint. The town sign was painted gold. In 1654, Master Martin Meziřický covered the corridor, which had once been the yard between the two original medieval houses, with a vault. In 1660, a new staircase was added in the central part of the building. In 1761, another fire broke out in Banská Bystrica, damaging the town hall and other buildings in the town. After the fire, the Renaissance attic was removed, new Prussian-style vaults were built in multiple rooms, and a new façade was added. This work was overseen by Master Georg Friedrich. The last significant historic reconstruction took place in 1904, but it mainly concerned the yard wing (*Güntherová et al. 1967*, 47; *Sura 1982*, 110–113). The interior of the building has not yet been archaeologically surveyed, except for irregular investigations in part of the cellars and the fills of the vaults, notable for finds of impressive Late Gothic figural stove tiles analysed by *Mácelová* (*2005*). The backyard of the plot was surveyed in a single rescue trench by *Mácelová* (*1998*) and during excavations conducted in 2008–2009.

This archaeological survey was associated with the reconstruction of the current town hall. Although the contractor claimed no plans for digging during his work, many trenches were recorded by monitoring the construction. Their unplanned schedule prevented the implementation of any sophisticated excavation strategy, and under these circumstances, the decision to sample the excavated deposits for future research proved to be most significant. These deposits were analysed from 2008 to 2023 using approaches from various scientific disciplines to obtain specific data. There were additional reasons to investigate the deposits further, such as the lack of archaeo-environmental data in the region, the good preservation of organic materials, and the prominence of the site itself in the context of the town. The original aim was to acquire as much data from different perspectives as possible in order to establish a final alignment of the results as a starting point for further research. The data acquisition was also aimed at providing a foundation for a future environmental database of the region.

Methods

Archaeological excavation and documentation

During the fieldwork, multiple features were recorded (pits and walls labelled as ‘O’, layers labelled as ‘K’). Three pits were noted directly on the plot and targeted sampling was conducted in two of them. In pit O4, the focus was on the burned charcoal layer, while in pit O10, it was the damp deposit containing organic matter. A smaller sample volume (0.5 l) was extracted from pit O4, since the main aim was to retrieve material for radiocarbon dating. The sample from pit O10 was larger (1.0 l in total); the mass of the uncontaminated damp layer on the bottom was meant to be dug away, so a larger amount was taken. Most of the sample was used for flotation, while 0.3 l was saved for other types of analyses.

Pit O10 was of significant importance in this regard. As the feature was so rich in informational value, a novel approach to reverse documentation was attempted. The situation was photographed in 2008 with only eight digital snapshots, some aimed at details,

	Species	Species (lat.)	NISP	MNI	weight (g)
Domestic mammals	domestic cattle	*Bos taurus*	34	1	1912.60
Domestic mammals	domestic sheep	*Ovis aries*	1	1	33.83
Domestic mammals	sheep/goat	*Ovis/Capra*	4	1	45.85
Domestic mammals	domestic pig	*Sus domesticus*	6	1	71.0
medium mammal		–	4	–	35.75
big mammal		–	4	–	23.01
unident. Fish		–	1	1	
unident.		–	5	–	31.82
Total			**59**	**5**	**2153.86**

Tab. 1. Quantification of animal species representation. NISP – Number of Identified Specimens, MNI – Minimum Number of Individuals.

some represented parts of the section, and a few provided an overall view from different angles. Due to the aforementioned constraints, it was impossible to accurately locate the spatial situation during the fieldwork. The documentation was made only via an orthogonal method in reference to the building ground plan, which lacked absolute coordinates. As this method was considered insufficient given the importance of the data acquired, we reconstructed the situation by means of 3D-based modelling using artificial intelligence (AI; see details in *Online Supplementary Material 1*). The model was used to generate orthographic ground and section plans (*Fig. 3*) and can be utilised anytime as a source for any type of metric figures and absolute coordinates. The finished model is used as an interpretive tool of the site for the lay public, as it is published on the Sketchfab platform (*Online Supplementary Material 2*) and as an Augmented Reality application.

Archaeozoology

An assemblage of animal bones retrieved from medieval-dated contexts K001, O4, O9, and O10 was analysed (*Tab. 1*). Anatomical and taxonomical analyses were based on available publications from veterinarians, anatomists, and archaeozoologists (*Kolda 1951*; *Schmid 1972*; *Popesko 2007*; *Adams – Crabtree 2008*; *Bocheński – Tomek 2009a*; *2009b*; *France 2009*) and comparative data provided by K. Šimunková. Fragments that could not be reliably assigned to a species were categorised using auxiliary classifications commonly found in archaeozoological literature: big mammal (the size of a horse, a bovid, or a deer) and medium mammal (the size of sheep/goat, pig, roebuck, or larger dog) based on the size, weight, and structure of the bone fragment. The group of small ruminants selected as *Ovis*/*Capra* includes both species of the *Caprinae* subfamily – domestic sheep and goat. The differentiation of these related species was carried out following the methodologies of *Boessneck* (*1969*), *Payne* (*1973*), *Halstead* and *Collins* (*1995*), *Halstead et al.* (*2002*), and *Adams* and *Crabtree* (*2008*). *Von den Driesch*'s (*1976*) style of measurement and methodology was used. Furthermore, the analysed features on bones included cultural and taphonomic modifications, pathologies on bones (cutting, deformation of bone, etc.), preservation grade of the bone tissue after *Behrensmeyer* (*1978*), and heat marks (*Shipman et al. 1984*; *Thurzo – Beňuš 2005*). Both methods were used for the approximation

Fig. 4. Typologically sensitive finds from the plot. 1–6 – pit O4; 7–14 – pit O10; 14–20, 22, 23 – layer K001; 21 – layer K003 (photo by M. Miňo).

of animal age: epiphyseal fusion (*Zoetis et al. 2003*; *Reitz – Wing 2008*) and eruption and wear of teeth (*Payne 1973*; *1987*; *Grant 1982*; *Hillson 2005*).

Pottery

The pottery was analysed based on typologies by *Hoššo* (*1983*; *1996*) and *Ruttkay* (*1995*) and categorised into morphological and chronological groups, which were used for the relative chronology (*Fig. 4*).

Archaeobotany

The bulk sample coming from the deposit in pit O10 was analysed. Thus, the strategy for archaeobotany sampling on the site was not intense. Analysed samples were taken using a judgement sampling strategy (*Jones 1991*). The volume of the sample taken from the stratified context was standard for a permanently wet layer. To separate the archaeobotanical material from the sediment, we used a flotation tank washing combined with the wash-over method. Light ecofacts and artefacts (floating and capillary rising in the water column) were captured by a 0.25 mm sieve. Two samples of anthropogenic sediments were analysed: BB-R53/08 with a volume of 0.3 l and BB-B46/08 with a volume of 0.4 l (*Tab. 2*). The nomenclature of vascular plant taxa follows *Marhold* and *Hindák* (*1998*).

DNA

A portion of the deposit from the pit O10 was used to attempt to isolate historic human sedimentary DNA, as the feature was assumed to contain human biological material and was interpreted as a cesspit. Six samples were retrieved from the deposit: two high-volume and four low-volume samples. The size of the samples was adjusted to fit the isolation kits. Three different methods of isolation were used: (1) phenol-isolation – two samples with a higher amount of analysed material (approximately 10 g); (2) chelex-isolation – two samples with a lower amount of analysed material (approximately 0.5 g); and (3) isolation via paramagnetic particles – two samples with a lower amount of analysed material (approximately 0.5 g).

Dendrochronology

Pit O10 was the only archaeological feature that contained timber samples preserved well enough to be dated by dendrochronology. Four samples were analysed using the VIAS TimeTable measurement with the PAST 5 software interface (*Tab. 3*). The acquired curve was detrended and compared using a ‘window smoothing’ algorithm and to a standard chronology developed by T. Kyncl.

Radiocarbon dating

Seven samples were selected for radiocarbon dating (*Tab. 4*; *Tab. 5*). All can be identified as a part of the terrestrial biosphere, and their ages have different relationships to the dated archaeological events.

Category		Taxon (species)	Sample BB-R53/08	Sample BB-R46/08	Sum
cultivated plants	fruit	*Vitis vinifera*	–	3	3
cultivated plants	vegetable	*Daucus carota*	1	7	8
cultivated plants	oil or fiber-plant	*Linum usitatissimum*	–	2	2
wild species		*Agrostemma githago*	1	4	5
wild species		cf. *Anthemis* sp.	2	1	3
wild species		*Asteraceae*	–	1	1
wild species		*Avena/Bromus*	–	1	1
wild species		*Barbarea vulgaris*	–	1	1
wild species		*Bupleurum rotundifolium*	2	2	4
wild species		*Capsella bursa-pastoris*	–	1	1
wild species		*Carex/Scirpus*	4	5	10
wild species		*Cornus mas*	–	1	1
wild species		*Crepis* sp.	–	3	3
wild species		*Fallopia convolvulus*	–	3	3
wild species		*Fragaria vesca*	–	1	1
wild species		*Glechoma hederacea*	–	–	1
wild species		*Humulus lupulus*	–	2	2
wild species		*Chenopodium album* agg.	7	18	30
wild species		*Lithospermum arvense*	–	1	1
wild species		*Papaver rhoeas*	–	1	1
wild species		*Polycnemum arvense*	–	–	1
wild species		*Polygonum lapathifolium*	2	1	3
wild species		*Potentilla argentea*	1	3	4
wild species		*Potentilla recta*	3	–	3
wild species		*Potentilla reptans*	–	2	2
wild species		*Potentilla supina*	–	1	1
wild species		*Prunus/Cerasus*	–	1	1
wild species			–	2	2
wild species		*Ranunculus acris/repens*	2	–	2
wild species		*Ranunculus repens*	–	1	1
wild species		*Rubus fruticosus*	–	2	2
wild species		*Rubus idaeus*	2	5	7
wild species		*Rumex acetosella*	–	1	1
wild species		*Rumex crispus/obtusifolius*	–	1	1
wild species		*Rumex* sp.	1		1
wild species		*Setaria viridis/verticillata*	2	11	14
wild species		*Silene vulgaris*	–	1	1
wild species		*Silene* sp.	–	1	1
wild species		*Solanum dulcamara*	–	1	1
wild species		*Solanum nigrum*	–	2	2
wild species		*Stachys arvensis*	1	1	2
wild species		*Stachys/Ballota*	–	2	2
wild species		*Tanacetum vulgare*	6	1	7
wild species		*Veronica hederifolia*	–	–	1
wild species		*Vicia tetrasperma/hirsuta*	–	–	1
wild species		*Quercus* sp. (cover)	–	4	4
wild species		indet.	6	64	71
Total			**43**	**166**	**221**

Tab. 2. Identified plant taxa.

ID	Species	Tree ring count	Date od falling	Remark	Figure
R43/08	*Abies alba*	27	summer 1813	low tree ring count for reliable dating, best position TBP 4, 63; THO 4,49; GL 83,3% ABNCAR15 (T. Kyncl)	*8:B*
R44/08	*Larix*	109	winter 1131/1132	low reaction for standard chronologies and surrounding samples, identified after AMS date was known	*8:A*
R52/08_1	*Quercus* sp.	64	after 1336	lower correlation, TBP 2,46; THO 3,31; GL 72,7% morges2010det (T. Kyncl)	*8:C*
R52/08_2	*Abies alba*	122	after 1346	TBP 6,71; THO 8,3; GL 73,8% ABNCAR15 (T. Kyncl)	*8:D*

Tab. 3. Results of dendrochronological dating.

Lab code	Material	Species	Stratigraphic unit (SU)	Stratigraphic phase	Archaeological event
CRL22_0835	animal tooth	*Bos taurus*	O4	1. 13–15th century	formation of the oldest settlement
CRL22_0829	charcoals	–	K001.1	4. 15/16th century	fire and site 'cleaning'
CRL22_0830	wood	*Larix*	O10	4. 15/16th century	fire and site 'cleaning'
CRL23_0171	wood	*Larix*	O10	4. 15/16th century	fire and site 'cleaning'
CRL23_0172	wood	*Larix*	O10	4. 15/16th century	fire and site 'cleaning'
CRL22_1458m	seed	*Vitis vinifera*	O10	4. 15/16th century	fire and site 'cleaning'
CRL22_1459	seed	*Cornus mas*	O10	4. 15/16th century	fire and site 'cleaning'

Tab. 4. Samples used for radiocarbon dating and their interpretation.

Lab code	Conventional ^{14}C age BP	Calibrated unmodelled interval (2σ), yrs cal AD	Calibrated modelled interval (2σ), yrs cal AD	Agreement index
CRL22_0835	688±14	1278–1302 (82.4%)	1279–1302 (59.6%)	79.8%
		1369–1378 (13.1%)	1366–1382 (35.8%)	
CRL22_0829	551±14	1326–1348 (16.5%)	1326–1348 (16.0%)	97.6%
		1394–1423 (78.9%)	1394–1423 (79.4%)	
CRL22_0830	1031±15	993–1026 (95.4%)	–	–
CRL22_1458m	306±17	1510–1593 (74.6%)	1518–1592 (78.5%)	102.1%
		1618–1645 (20.9%)	1620–1644 (17.0%)	
CRL22_1459	1217±17	709–716 (1.7%)	–	–
		772–882 (93.8%)		
CRL23_0171	947±16	1035–1054 (14.9%)	–	–
		1062–1158 (80.6%)		
CRL23_0172	906±16	1046–1085 (42.7%)	–	–
		1095–1103 (1.5%)		–
		1124–1213 (51.2%)		

Tab. 5. Radiocarbon data of individual samples and their modelled intervals with a 95.4% probability.

Sample / Element	O10	O4
P	3218.00	8863.00
S	2327.00	544.00
Mg	2708.15	4490.55
Al	12245.70	13482.90
Cr	153.60	106.40
Mn	420.70	718.20
Fe	14045.00	16044.70
Co	11.50	10.85
Ni	90.05	66.65
Cu	47.55	149.95
Zn	77.75	168.25
Pb	156.50	133.80

Tab. 6. Concentrations of selected elements in soil samples. The values are in mg/kg and represent the mean concentrations of composite three-fold sample measurements. LOQ = 10 mg/kg.

Archaeobotanical samples were inspected and mechanically cleaned. They were then repeatedly washed with 0.5 M HCl, 0.1 M NaOH, and 0.01 M HCl, with distilled water wash steps in between (*Gupta – Polach 1985*; *Jull et al. 2006*). The bone sample was cleaned, ground to a fraction of 0.5–1 mm and finally washed under the same conditions as the other samples. The isolated collagen was gelatinised at 90°C, filtered, and dried at 60°C to reach a constant weight. The yield of bone collagen was 19.3 mg/g. All samples, with a small amount of CuO, were torch-sealed under a dynamic vacuum into a quartz glass tube and combusted at 900°C. The resulting carbon dioxide was purified and graphitised (*Orsovszki – Rinyu 2015*).

All samples were measured using the Multi-Isotope Low-Energy AMS System (MILEA) in the Nuclear Physics Institute of the Czech Academy of Sciences (*Kučera et al. 2022*). The resulting ^{14}C activities were calibrated using OxCal v4.4 software and the calibration curve IntCal20 (*Bronk Ramsey 2009*; *2017*; *Reimer et al. 2020*).

To identify the true calendar age of the analysed timber, we decided to employ a high-resolution ^{14}C wiggle-matching method (*Pearson 1986*; *Bronk Ramsey et al. 2001*). Individual tree rings (more than 120) were identified in cross-section, and three of them were sampled in the middle part using the known gaps between the sampled tree rings. The last retained ring was extrapolated by knowing the gap (63 years) since the last sample (CRL22_0172). Also, sequential phases combining radiocarbon and calendar data were generated through Bayesian modelling (*Bronk Ramsey 2009*).

Total concentrations of selected elements in sampled soils

The dry homogenised soil samples were ground to a fine powder. A subsample of 100 mg of the investigated material was used for microwave digestion (Mars) with nitric and hydrochloric acid in a solution ratio of 1:3. The concentration of phosphorous and sulphur was measured by optical emission spectroscopy with inductively coupled plasma – ICP-OES (Perkin Elmer, The Optima 8000) by 3-point individual calibration. The concentrations of Mg, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, and Pb were determined by mass spectrometry with inductively coupled plasma (ICP-MS) using 5-point individual calibration. To obtain a higher accuracy of the results, the final value was calculated as the mean concentration of three individually analysed subsamples (*Tab. 6*).

Results

Relative chronology

The stratigraphic situation of the plot was determined and visualised by a Harris Matrix (*Harris 1989*; Harris Matrix software; *Fig. 5*). A medieval deposit was documented (K001), bordered on its surface by a charcoal horizon (K001.1; *Fig. 6*). The deposit contained medieval pottery dated typologically to the period from the 14th to the turn of the 16th century AD. The pottery included one fragment of a glazed stove tile with figural relief (*Fig. 4*: 23). The figure on the relief could not be linked to any known published scene, but it corresponds stylistically to an older phase of figural stove tiles dated to the mid-15th century (*Mácelová 2005*; *Kvietok – Mácelová 2013*). The charcoal horizon is thus dated based on the artefacts to the late part of the 15th century or the early 16th century. It may be related to the great fire of 1500 AD (*Baláž 2002*, 10).

Apart from this deposit, only three other features could be identified as medieval based on the finds they contained. All three were excavated in sunken features. Feature O4 was a prolonged pit surveyed only in a narrow cross-sectional trench. The pit could be dated by pottery to the 13th–15th century. The pit was covered by the medieval deposit (K001). Feature O9 was a small, probably round waste pit. It contained only a single late medieval potsherd in the upper part of the fill (K007). The pit was disturbed by wall O8, which was dated by stratigraphy to the 16th century at the earliest. Based on this fact, the medieval age of this pit was assumed. The last medieval feature was a large pit situated between the pillars supporting the backyard façade of the town hall (O10). This pit had already been disturbed earlier by the 20th-century entrance to the basement. The pit was partially covered by the supporting pillars and a burned clay deposit, which might represent the destruction of the medieval wattle and daub phase of the building (K006; *Fig. 3*). The pit contained multiple pottery fragments and organic material, including larger pieces of timber that were retrieved (R43/08, R44/08, R52/08-1, R52/08-2). Two samples of the deposit were taken from the pit fill (BB-R53/08, BB-B46/08). The pottery from the pit dated the feature to the turn of 16th century. Since the pit was located under the oriel window toilet, it was interpreted as a cesspit (*Fig. 3*). The burned deposit over the cesspit (K006) did not contain any finds, so it was only considered to be younger than the pit (early 16th century or later). All the sunken features shared one common trait – a buffer of up to 40 cm-thick substratum clay that was soaked with organic matter from the pit fill (*Fig. 3*).

The medieval stratigraphy was covered by four Early Modern period deposits dated to the 16th–17th century (K002-K005). This part of the stratigraphic sequence includes stone walls O1, O2, and O8, which form a two-room layout oriented rectangularly to the axis of the plot. Walls O1 and O2 seem to continue northeast to the neighbouring plot on Kapitulská Street. Wall O2 is in line with the border between the two plots on Kapitulská Street.

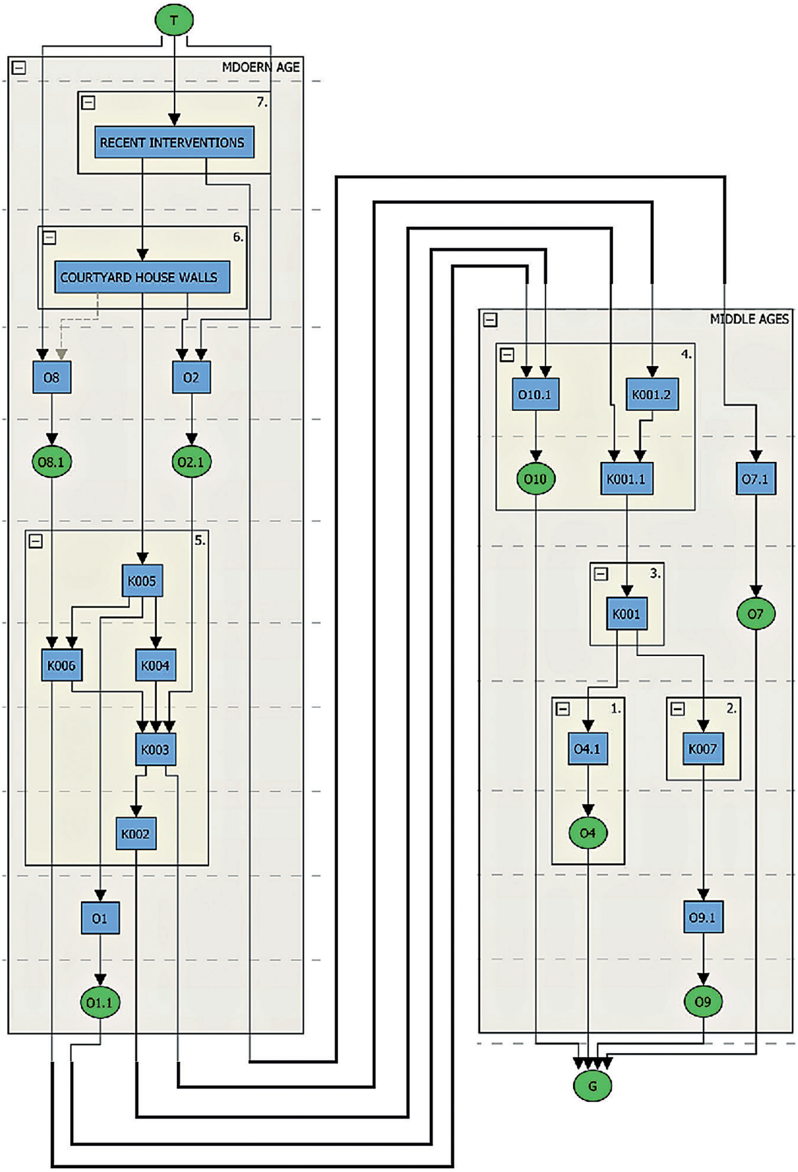

Fig. 5. Archaeological stratigraphy recorded by the Harris matrix diagram. Middle Ages: 1 – 13th–15th century; 2 – 14th–15th century; 3 – 14th–15/16th century; 4 – 15th/16th century. Modern period: 5 – 16th–17th century; 6 – 17th–19th century; 7 – 21st century. Stratigraphic units (SU) – deposits (blue) and surfaces (green): G – geology; K001 – grey viscous deposit; K001.1 – charcoal horizon; K001.2 – slag; K002 – brown deposit; K003 – thin yellow deposit; K004 – grey cultural layer; K005 – brown-yellow deposit from modifying terrain; K006 – deposit with burnt lumps of clay; K007 – top deposit of pit O9 backfill; O1 – quarry stone masonry; O1.1 – excavation for masonry O1; O2 – quarry stone masonry; O2.1 – excavation for masonry O2; O4 – excavation for waste pit; O4.1 – waste pit fill; O7 – quarry stone masonry; O7.1 – excavation for masonry O7; O8 – stone masonry; O8.1 – excavation of stone masonry O8; O9 – excavation of a small shallow waste pit; O9.1 – grey wet deposit with organic residues; O10 – excavation of a sunken cesspit; O10.1 – fill with a high content of organic residues; T – top surface.

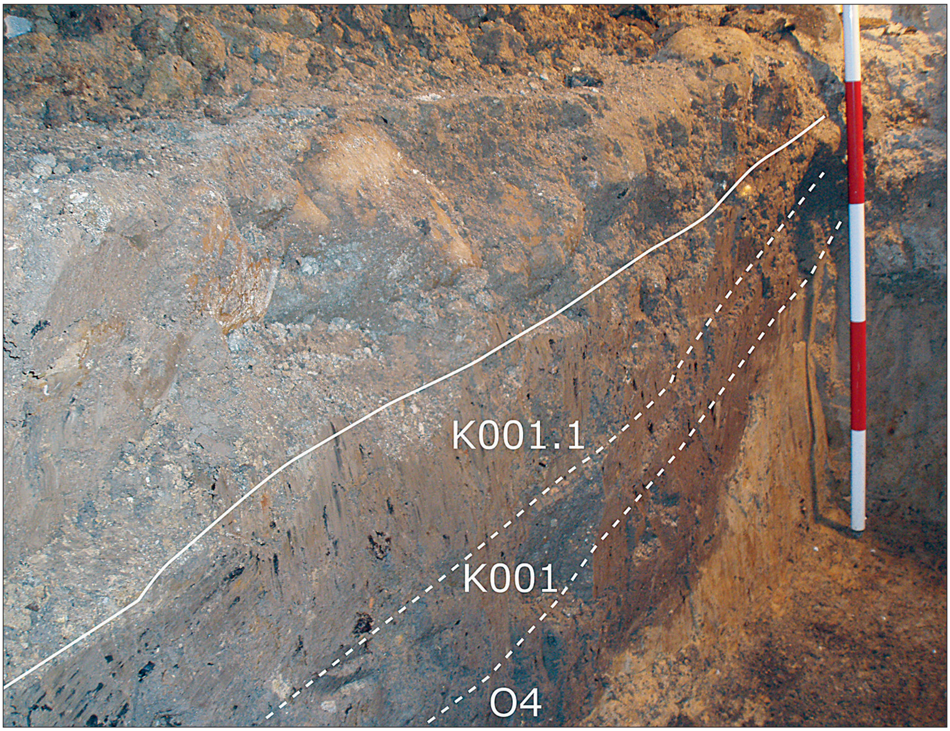

Fig. 6. Documented pit O4 containing medieval deposits – fill (K001) and charcoal horizon (K001.1) (photo by M. Miňo).

Inside the northeast room of this layout, the top part of a stone-lined well (O6)[1] was documented. Another undated feature was wall O7, which was parallel to walls O1 and O2 but lies deeper in the back of the plot.

The pottery assemblage found on the premises of the town hall is represented mostly by so-called grey ware (*Fig. 4*). The oldest identified vessel is a 13th-century pot with an everted rim (*Fig. 4*: 1). The pottery assemblage consists predominantly of rounded pots with collared rims occurring in all stratigraphic contexts. This form is the most common vessel type throughout the medieval period in the area, being used from the 14th century up to the Early Modern period. The only exception is the shouldered bowl with an everted, thickened, and hooked rim (*Fig. 4*: 3). A collared rim is also typical for both examples of jugs with looped rod handles. Other (less numerous) shapes include lids, mainly collared lids with an integrated clubbed knob. The profile of the lids, together with marks from cutting the vessel off the wheel with a string, links them chronologically with the set of collared bowls. The identified vessel forms included an undecorated Late Gothic waisted

[1] Even though the bottom of pit O10, interpreted as a cesspit, was at the level of the groundwater, we do not expect its contamination. The cesspit has a small visible amount of contaminated subsoil and its distance from the well is c. 13 m. Notably, the well and the cesspit belonged to two separate plots in the Middle Ages.

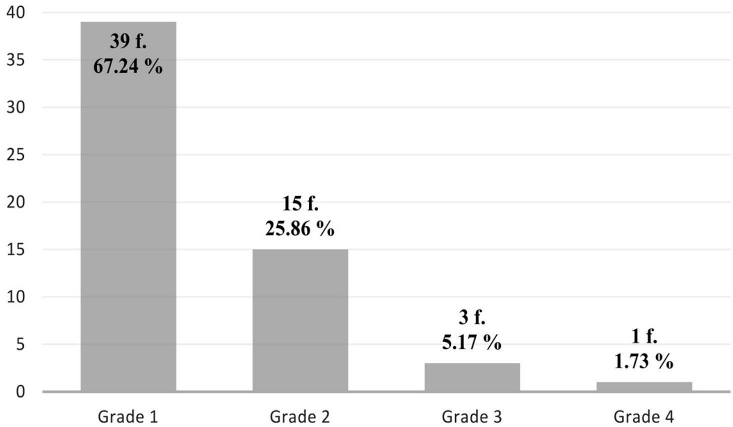

Fig. 7. Ratio of bone preservation under the criteria of *Behrensmayer* (*1978*).

beaker with a collared rim and an unusually high neck. This Bratislava type beaker – phase II according to *Hoššo* (*1996*) – can be dated to the mid-15th century (*Fig. 4*: 22). It is interesting that there is no single example of oxidised glazed waisted beakers with an inverted rim from the turn of the 16th century known from the town castle (*Ušiak 1997*; *1999*). However, their unglazed predecessors were identified (*Fig. 4*: 14, 16). Decorated pottery is scarce in the assemblage, which is typical for the region and time. The documented decorative patterns are typical as well. They consist of roulette and running incised wave line. In a single instance, a finger-pressed decoration on the pot mouth and a band of incised lines was documented (*Fig. 4*: 19). Most of the assemblage is dated to a single time frame from the mid-15th to the early 16th century. The assemblage is quite uniform in terms of technology and local provenance. Only one piece of white clay pottery from a different region (likely Kremnica or Hont County) was recorded.

Absolute chronology

Well-preserved organic material in cesspit O10, dated by stratigraphic relations into the 15th/16th century, allowed the use of dendrochronological analysis as well as radiocarbon dating. First, four samples of timber (*Tab. 3*) were analysed by dendrochronology. All of them showed traces of carpentry work (*Fig. 8*), so they can be considered relevant for dating human activity on the plot. Two of the samples were identified as *Abies alba*, one as *Quercus sp.*, and one as *Larix*. Only two samples, *Abies* (R43/08) and *Larix* (R44/08), preserved the last outermost tree ring. The other two samples could be determined only as *terminus post quem.* The *Abies alba* sample (R43/08) was a carpenter's splinter and thus provided only a *terminus post quem* date with a low scale of precision. The *Quercus* (R52/08_1) and *Abies alba* (R52/08_2) samples were sections of boards, so the last outermost tree ring was not present in either sample. The most problematic was the *Larix* sample (R44/08; *Fig. 8*). It represented a section of a half-pole, with one end roughly cut into a pointy shape by an axe; burn marks were found at the opposite end. The pole was made from the entire width of the tree trunk, including the outermost tree ring. The circumference of the trunk in its broadest part was only 38 cm, but 109 tree rings in total were identified. This would suggest a much broader trunk. Another important observation was that the tree rings

Fig. 8. Analysed timber samples: A – *Larix* (R44/08) as a section of a half-pole with traces of burning and carpentry work, B – *Abies alba* (R43/08); C – *Quercus sp.* (R52/08_1); D – *Abies alba* (R52/08_2) (photo by B. Styková).

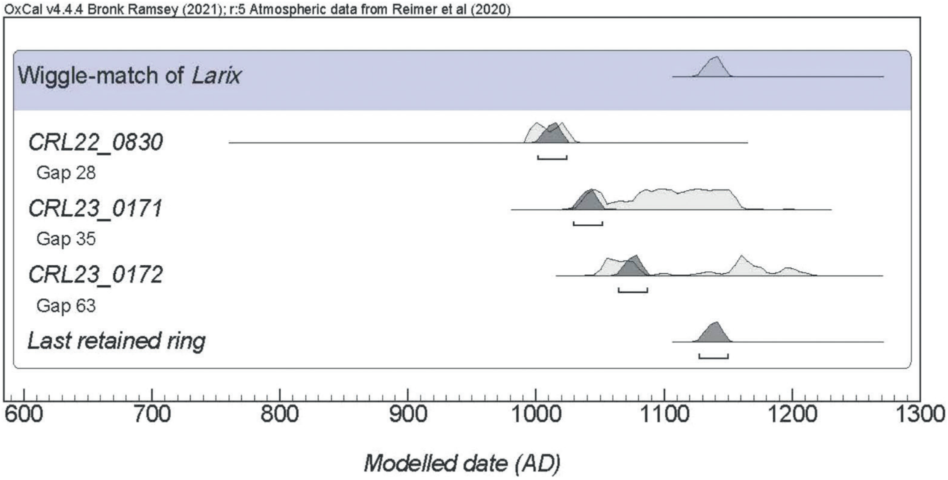

Fig. 9. Wiggle-match result using extrapolation of the last preserved ring.

were not uniform around the whole circumference (some might be too subtle for identification in certain parts). This indicates that the tree had to grow in a specific location, which is why the sample initially could not be dated by the dendrochronology method.

Separately, the same *Larix* timber was radiocarbon dated. Three individual tree rings were sampled (CRL22_0830, CRL23_0171, and CRL23_0172) and used for the wiggle-matching method. With knowledge of the 63-year gap between them, his approach allows the model to estimate the age of the last retained ring within the range of *1127–1150 cal AD* with a 95.4% probability (*Fig. 9*). This wiggle-match has good overall agreement (A_{comb} = 83.7%, A_n = 40.8%, n = 3).

After the radiocarbon dating, the matching sequence in dendrochronology was identified (*Fig. 10*), which narrowed the window for a possible match. The obtained interval of *1127–1150 cal AD* showed the highest correlation with statistical data for a cut date in the winter of 1131/1132 AD (statistical probability values: TBP 3.93; THO 2.24; CC 0.25; Gl 59.7; OLP 108). This is the most probable date for the felling of the tree under the circumstances. The reliability of this date needs to be further verified in the case that more samples of the same species for the date are collected. There is not much comparable data available, so the value of the source data is lower.

For the absolute chronology of the site, more samples were analysed using the radiocarbon dating method. Two seeds of annual plants (C3 plants; CRL22_1458 and CRL22_1459) from pit O10 were sampled, as this type of material contains a C^{14} signal from the year of the plant's death. Furthermore, one animal tooth obtained from waste pit O4, which is older (13th–15th century) than cesspit O10 according to stratigraphy (*Fig. 5*), was also sampled. Using archaeozoological methods, the tooth was identified as a lower M1/2 tooth (first or second lower molar) from *Bos taurus*. The estimated age of the tooth approaches the time of animal death.

Banská Bystrica's great fire, mentioned in 1500 AD, and its identification on the site was the next target of the radiocarbon analysis. Stratigraphy and the arrangements of the charcoals in deposit K001.1 suggest deposition in a short time interval, such as during a fire

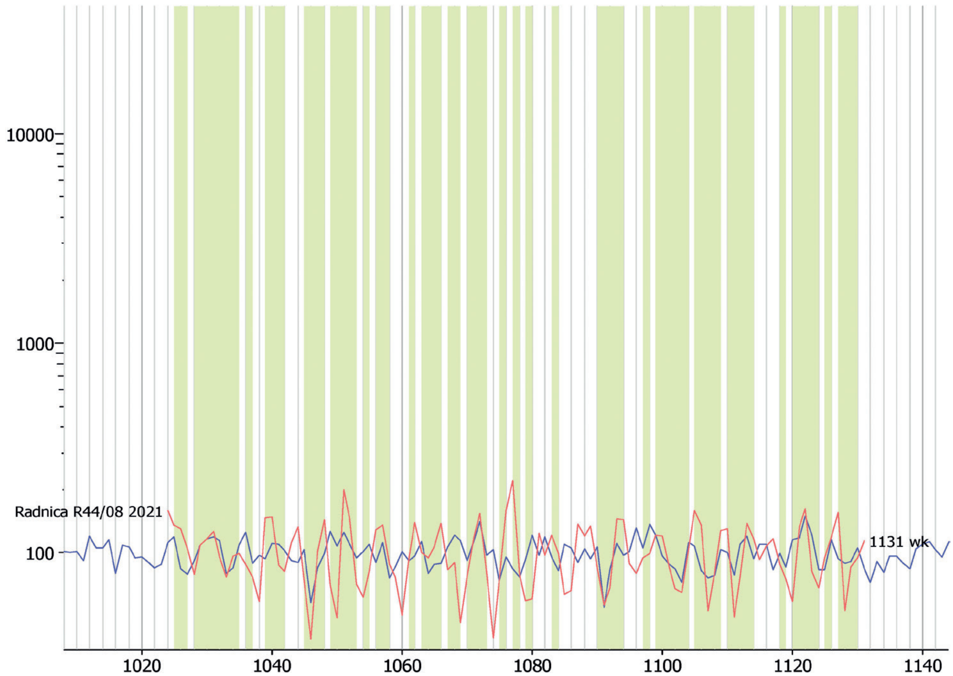

Fig. 10. Dendrogram of *Larix* timber (R44/08) from pit O10.

event. The charcoals (CRL22_0829) from this deposit, which is contemporary with cesspit O10 and later than waste pit O4 and deposit K001, were dated. Unfortunately, the species and part of the wood cannot be identified and, therefore, the sample represents only the *terminus post quem* for when the fire may have occurred (*Tab. 5*).

Three radiocarbon and three calendar dates (dendrodates: *Quercus* – R52/08_1, *Abies alba* – R52/08_2, and the known town fire in 1500 AD) were used for sequential phases labelled Sequence 1–3 (*Fig. 11*), generated by Bayesian modelling. These dates were arranged according to their character (accurate data or *terminus post quem*) and the archaeological phases based on stratigraphy. *Cornus mas* and the wiggle-matching result from the *Larix* do not reflect the use phase of the archaeological feature that we wish to date, and therefore we did not include them in the model. *Cornus mas* (CRL22_1459) belongs to the latest feature (O10), in the stratigraphy dated to the 15th/16th century, but its unmodelled interval is 709–882 cal AD (95.4% probability). Usually, the archaeobotanical remains of annual plants allow for the dating of the archaeological objects in which they were stored or their deposition. In this case, seeds of *Vitis vinifera* (CRL22_1458m) and *Cornus mas* (CRL22_1459) fall into two distinctly different time ranges (*Tab. 5*). This discrepancy is further addressed in the discussion. Using radiocarbon and dendrochronological dating, the *Larix* (R44/08) was most probably felled and used to build a wooden construction (I) in winter 1131/1132 AD. This provides evidence of previous settlement of the plot or its nearby area, which dates back to the 11th or 12th century AD, before the first archaeological phase according to a Harris matrix diagram. Its deposition in later feature O10 clearly documents the reuse of wood.

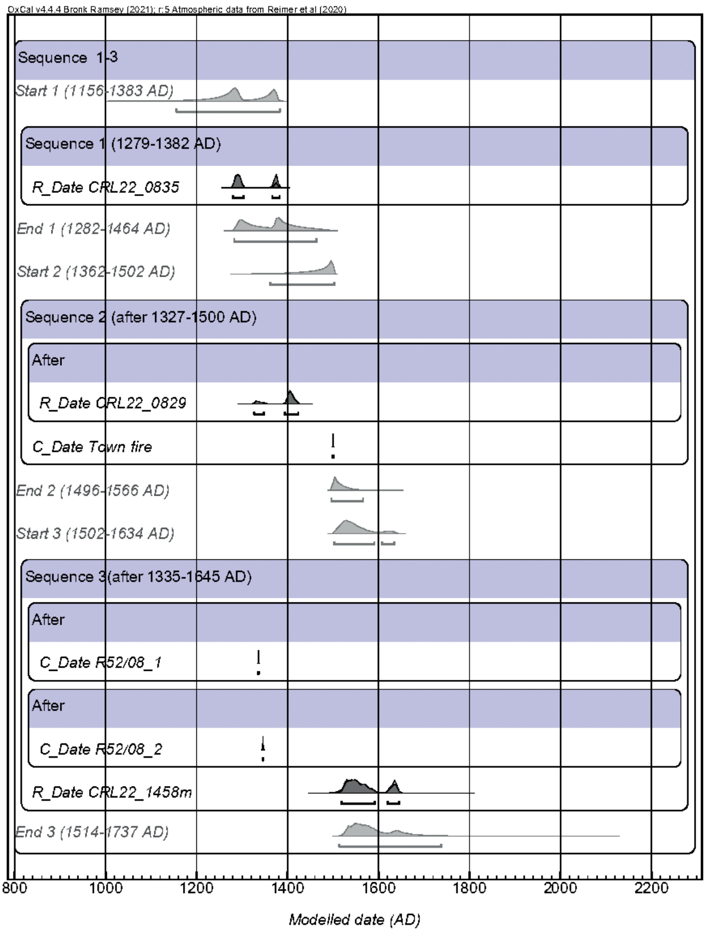

Fig. 11. Final sequence model based on Bayesian stratigraphic analysis performed in OxCal v4.4. software (*Bronk Ramsey 2009*; *2017*) using the IntCal20 calibration curve (*Reimer et al. 2020*).

The first sequence of the Bayesian model (*Fig. 11*) with the *Bos taurus* tooth sample (CRL22_0835) allows for dating waste pit O4 as well as the first archaeological phase. The modelled interval is in the range of *1279–1382 cal AD* (95.4% probability), which indicates ordinary activity at the site.

Even though the charcoal samples (CRL22_0829) are related to the town fire in 1500 AD, they represent the period before that. These dates were incorporated into the second sequence using the After function. The modelled interval after *1335–1500 cal AD* (95.4% probability) represents the time the tree was felled and used for a wooden construction (II), which subsequently burned down, most likely during the town fire in 1500 AD.

Lastly, the third sequence contains two dendrodates (R52/08_1, R52/08_2) and a *Vitis vinifera* seed sample (CRL22_1458m) dated 1518–1644 cal AD (95.4% probability). In this case, we used the After function again. Based on the archaeological dating of feature O10 to the 15th–16th century AD, we can lean towards attributing a younger age to this seed. It represents the activity of the settlement just before the establishment of the historic town hall in the second half of the 16th century.

Environmental analysis

Archaeozoology

The osteological material consisted of 58 bone fragments with a total weight of approximately 2.2 kg, of which only 13 bones (90.58 g) could not be categorised. The preserved condition of the bones was relatively good, assessed as grade 1–4 under the criteria of *Behrensmeyer* (*1978*; see *Fig. 7*).

Thus, the bones were not significantly affected by abiotic factors of decomposition (erosion, effect of soil pH, etc.). The sedimentation of the bone fragments was finished 3–6 years after the death of the animal. From the analysed collection of bones, domestic cattle (*Bos taurus*), domestic pig (*Sus domesticus*), domestic sheep (*Ovis aries*), and a group of small ruminants, likely sheep/goat (*Ovis/Capra*), were identified. Based on bite marks on the bone of a domestic pig (R51/18_5), we can assume the presence of a domestic dog (*Canis familiaris*) at the site. Fish bones were acquired from the sediment flotation of pit O10, but were not examined.

The domestic cow (*Bos taurus*) was represented by at least one individual. The age was estimated to be 42 months, and the sex was identified as female. It was not possible to calculate the withers height. Unevenly ground molars were documented on the mandible. Cut marks were documented on the left forehead (*Fig. 12*: A, B). The same marks were found on a lumbar vertebra, a radius and a talus. Some bone fragments showed changes of colour to brown (assessed temperature 285–525°C) and black (525–645°C) due to heat exposure.

Domestic sheep were represented by at least one individual, but butchering age, sex, and withers height could not be determined. The group of small ruminants (*Ovis/Capra*) was represented by at least one individual. Butchering age was estimated at 23 to 42 months. Sex and height could not be determined. One bone showed changes in colour to brown-black (assessed temperature 285–525°C).

The domestic pig was represented by at least one individual. The withers height of the individual was derived from the total length of the metatarsus, which measured 732 mm (*Teichert 1969*). Butchering age and sex could not be determined. Cut marks were detected on a vertebra and a rib (*Fig. 12*: C) and dog bite marks were found on a second vertebra. Some of the bones exhibited changes in colour to brown (assessed temperature 285–525°C).

Archaeobotany

From the total volume (3.7 l), 221 plant macroremains (only plant seeds) were extracted. In general, it could be stated that the average density of finds per litre of sediment in almost all of the samples was high, within the interval of 4–415 f/l. There are two reasons for this high density: the context allowed for the long duration of plant material accumulation, and the material is conserved by water, as constantly wet contexts usually hold more organic matter. The largest part of the collection consisted of wild species, with 208 finds representing 38 identified taxa (*Tab. 2*). According to their ecological demands, they can be divided into five main categories: 1. a mixture of meadow species (*Avena/Bromus*), 2. weeds (*Agrostemma githago*, *Papaver rhoeas*, *Stachys arvensis*, *Solanum nigrum*, *Tanacetum vulgare*, *Capsella bursa-pastoris*), 3. moisture-loving species (*Carex/Scirpus*, *Potentilla reptans*, *Ranunculus repens*, *Solanum dulcamara*), 4. species common in riparian vegetation

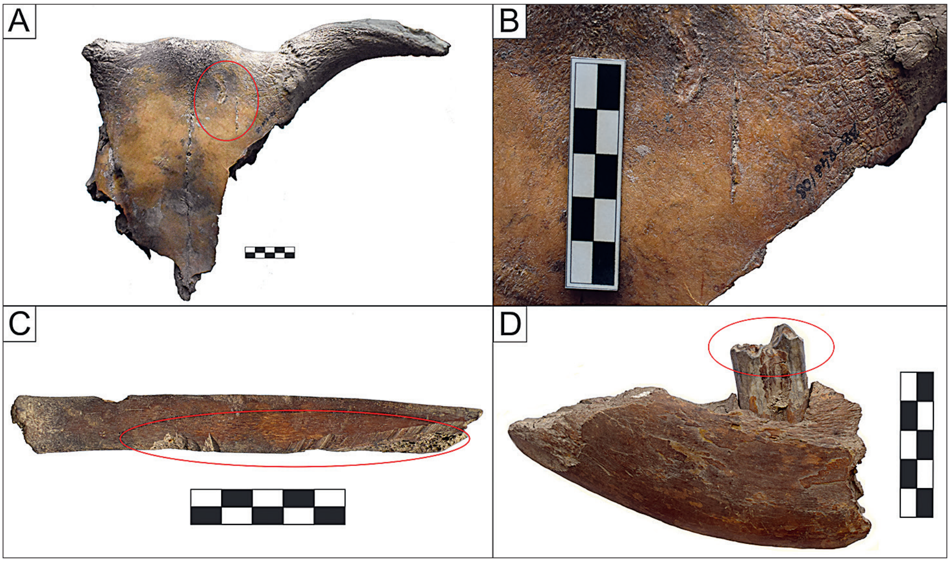

Fig. 12. Analysed bones with documented marks: A – left forehead of domestic cattle (*Bos taurus*) with cut marks; B – detail of cut marks; C – rib of domestic pig (*Sus domesticus*) with cut marks; D – mandible of domestic cattle (*Bos taurus*) with unevenly ground molar (photo by K. Šimunková).

(*Glechoma hederacea*, *Humulus lupulus*), 5. species typical for therophyte communities on cultivated soils and freshly disturbed ruderal habitats (*Barbarea vulgaris*, *Chenopodium album*, *Fallopia convolvulus*, *Setaria viridis*, *Silene vulgaris*),

The second documented group, with 13 finds, consisted of cultivated plants. They were represented only by categories of fruits, fibre-plants, and vegetables. Three taxa were specified – grapevine (*Vitis vinifera*, 3 finds), common flax (*Linum usitatissimum*, 2 finds), and carrot (*Daucus carota*, 8 finds). Common finds of plants as cereal grains or their chaffs and grain legumes are missing from the assemblage.

Total concentrations of selected elements in sampled soils

The results of ICP-MS and ICP-OES analyses (*Tab. 6*) reveal that the concentration of sulphur in the sample from the charcoal layer over pit O4 is 544 mg/kg, whereas in the sample from the bottom of pit O10 reaches 2327 mg/kg. The content of phosphorus also shows a considerable difference: 8863 mg/kg for feature O4, and 3218 mg/kg for feature O10.

DNA

The quantification analysis did not identify traces of human biological material in any of the samples. In samples isolated by the phenol and Chelex method, PCR inhibition of quantification analysis was recorded. However, in samples processed with paramagnetic particles, PCR inhibition of quantification analysis did not occur. Subsequent DNA analysis via STR systems did not confirm the occurrence of any biological material of human origin.

Discussion

Chronology and interpretation

The acquired chronological dates can be contextualised spatially and chronologically based on typological dating, which is still quite scarce. An early medieval layer dated to the 9th century was documented on a nearby plot at SNP Square 3. Early Medieval pottery was also documented further down the slope on Cikkerova Street. The site consisted of a thick layer that continually accumulated until the Early Modern period. The layer might be interpreted as a trash dump site by the riverside or as an accumulation of layers eroded from the higher parts of the slope. The list of pre-charter (1255) finds from the historical centre of Banská Bystrica could be supplemented with the single find of a 12th-century pot bottom found on Štefan Moyzes Square and a coin hoard from the 11th–12th century, which is localised only broadly within the town centre (*Hrašková et al. 2009*; *Mácelová 2013*, 74–75). All of these finds are dated only by means of typology, and the dating of at least some of them might be controversial. However, they provide a hint of the continuity of the settlement. More precise dating methods need to be applied for further conclusions. The find of an 8th/9th century *Cornus mas* in a pit is surprising but not necessarily problematic. A contemporary layer was found nearby (SNP Square 3, *Mácelová 2013*, 74–75). Therefore, it might have entered accidentally or been brought into the pit with other material (e.g. a collapsed wattle and daub wall, which might include parts of older finds in the clay, or intentional fill as part of cleaning, etc.).

The find of a *Larix* pole dated to the first half of the 12th century might play an important role in understanding the continuity of settlement. Due to cut marks on one end, the pole might indicate that it was originally used as part of an unknown building structure on the plot. The fact that it was found in a pit with artefacts dated to the mid-14th (wood boards) to early 16th century (pottery) suggests a continuous use of the plot from the 12th century to the modern age. Several potsherds from the same pit, originating from a vessel made using archaic technology, might support this theory; however, any typologically relevant part of the vessel is missing. Thus, there remains the possibility that the pole was brought from a different plot in the town. In that case, it is still an important find indicating the continuity of settlement activities in the town since the 12th century. The burned end might indicate the discard event of the pole. Considering the homogenous pottery assemblage from the turn of the 16th century found in the pit, we assume the discard time to be around the time of the great fire in 1500 AD (thus the burned end?). The association of the burn marks with anti-decay measures is less likely due to the overall short length of the pole, which suggests that a significant part of its original size might have burned off. Until around the time of the great fire event, the plot was probably used as part of a building erected on the site and might have eventually been reused during any rebuild events. Another explanation is the continuous use of the waste pit or cesspit, perhaps with periodical cleaning since the 12th or even the 9th century. The latest absolute date in this feature comes from a dendrochronologically dated 19th-century wood splinter. The presence of this artefact in the collection is surprising. However, the possibility of intrusion during the construction of a secondary entrance to the cellars might offer an explanation. After all, cesspits could have a very long lifespan, especially if maintained well (*Smith 2020*, 454). Typically, only the middle part of the cesspit was emptied, allowing older waste sediments to remain on the edges as later ones accumulated in the centre. Nonetheless, with the long lifespan of cesspits, a specific type of form and construction can be expected (according to *Smith 2020*, 447–454). Hay was commonly used as a sanitary layer to mitigate odours (*Bain – King 2011*; *Smith 2020*) and as an accelerator for the breakdown of organic materials (*Atta et al. 2013*). This usage is supported by archaeobotanical finds of grass seeds (according to *Smith 2013*, 539), as was the case in pit O10.

Carbon, nitrogen, sodium, and phosphorus are among the most important chemical elements indicating human activity, while potassium, magnesium, sulphur, copper, and zinc are less significant (*Holliday – Gartner 2007*). For the detection of soils affected by settlement activities, phosphorus is a particularly suitable marker since soil chemical assessments assume that during the time a certain place was inhabited, there was an increase in the surface deposition of organic material, which, among other fractions, contains the organic form of phosphorus (*Schlezinger – Howes 2000*). Similar activities include the removal of household waste and faeces (*Terry et al. 2000*). In both analysed cases, phosphorus reached higher concentrations (O10 – 2327 mg/kg, O4 – 8863 mg/kg) than the average for soils, indicating that both places represent soils affected by anthropic activities. In the case of top layer K001.1 filling pit O4, the concentration reaches considerably higher values. The high concentration of phosphorus could refer to a fire event, as it is present in wood ash in higher concentrated forms. According to the dating of the charcoals, this could possibly be linked to the town fire of 1500 AD. The sulphur content in feature O4 could also serve as a marker of anthropic activity, indicating the presence of a site used as a cesspit, since both phosphorus and sulphur are contained in human faeces. This statement, however, should be supported by multiple sampling of the site.

Another attempt to confirm the interpretation of feature O10 as a cesspit was the DNA analysis, based on the assumption that human faeces and urine are indicators of this interpretation. The presence of these biological materials might result in increased traces of sedimental DNA. Analysis of the retrieved samples did not prove any occurrence of biological material of human origin. In four of the six samples, the quantification DNA analysis was inhibited. Generally, there is a need to use a more appropriate isolation method aimed at higher input quantity and the removal of PCR reaction inhibitors when assuming that the presented deposit contained some human DNA in a detectable quantity and quality. In at least two samples, no evidence of preserved biological material was detected. This leads to the conclusion that the preservation of biological material, particularly human DNA in this case, is highly influenced by physical, chemical, and microbiological conditions, as well as the input amount, character, and quality of the biological material. However, another possible conclusion is that the deposit did not contain any human biological material, and the interpretation of feature O10 as a cesspit might not be correct. This is also supported by the absence of bran in the archaeobotanical sample, as bran indicates excremental waste (*De Cupere et al. 2022*). There is still a chance to validate the interpretation through the identification of coprolites by micromorphological analysis of the remaining part of the sample deposit. The dimensions of pit O10 (4.4 m × min. 2.8 m) suggest it could have originally been the underground part of a temporary dugout dwelling used during the construction of the main house, which eventually ended up as a waste and cesspit. Although temporary dugout shelters are rarely preserved or recognised archaeological features, there are some examples, the most well-known being the Selepcheny house in Trnava (*Hoššo 2007*; *Žuffová 2009*, 55).

The historical analysis of architecture pointed out the evolution of the building from two different houses (*Sura 1982*, 110–113; *Staníková 1990*; *Sura et al. 1996*), and the spatial analysis of the plot seems to confirm this hypothesis. The plot width is 22 metres, which is double the size of an average historical plot in the town centre (11±0.5 m). Despite this, it could be said that analysed pit O10 originally belonged to a different house than pits O4, O9, and stone-lined well O6. The boundary between these plots might be preserved in wall O8, the archaeological date of which might possibly correlate with the written record of master Pankratz's 1555/1556 reconstruction of the town hall, which included the construction of walls around the yard (*Sura et al. 1996*, 29). According to a record from 1556, two individual houses had already been merged into one two-storey thoroughfare type mansion. The town hall was located upstairs, while other rooms were rented out. Various structures, such as a building by the well, an old brewery, a barn converted into a warehouse for brick, and a garden extending to the Hron River, were situated behind the main building (*Güntherová et al. 1967*, 47). The relationship between the mentioned building by the well and the archaeological record of the stone-lined well (O6) and surrounding walls (O1, O2, O8) is questionable.

The position of wall O2 and its proposed continuity to the northeast, in correlation with the axis of the plot boundary on Kapitulská Street, might suggest that part of the plot could have belonged to Kapitulská Street for some time. This scenario could only have occurred during the period between the year 1600, as depicted by the Ferrari map, and the mid-19th century, but this scenario seems unlikely. However, building activities extending across different plots in the town are already known (e.g. the Thurzo mansion).

Diet

The analysis of osteological material identified only domestic animals. The most numerous were cow bones. Even though the osteological material was not plentiful, it provided interesting information concerning the butchering age of animals. Only mature animals were detected (sheep aged 23–36 months, cows older than 42 months), which may indicate a primary focus on dairy products rather than meat. A later 18th-century written record suggests that even poorer citizens of the town typically raised 1–3 cows per family (*Jurkovič 2005*, 205). An interesting find was the mandible of a cow, which probably had tooth problems due to unevenly ground molars. Cut marks were found on the left forehead of this animal and they were also recorded on other species, specifically on their ribs, vertebrae, and long bones, indicating butchering and kitchen preparation of meat. The presence of heat marks on 11% of all bones indicates that these bones were related to baking waste. The assumed temperature that caused these marks were too low for the burning of the waste bones, which was common for the period. The animal bones reflect, on one hand, the dietary practices of the town's high society, and, on the other hand, they indirectly confirm the presence of one species unrecorded in osteological material – the dog. Although its bones were not found in the assemblage, bite marks on the bones of other animals (R51/08) indicate its presence. The absence of dog bones could be explained by the custom of the disposal of dog and horse carcasses outside the town, often around the gallows (*Boriová 2019*, 123). A late medieval horse burial at the Hron riverside excavated in what is now Cikkerova Street in Banská Bystrica might contribute to this as well. The burial was broadly dated by the presence of a late medieval horseshoe and atypical pottery. The pit in which the horse was buried was dug in the area covered by a thick organic layer with artefacts from a broad time span between Early Middle Ages to the Modern Age (*Hrašková et al. 2009*). The context most likely represents a waste disposal site. The find of fish bones is not surprising, as the last private owner, Mühlstein, left an estate that included a fishpond on the left bank of the Hron River (*Jurkovič 2005*, 205).

Archaeobotanical finds of cultivated plants did not yield much new information. However, they raise the question of why there are no cereals or legumes in the record. This absence might be attributed to various reasons, but cereals are present in the only other existing archaeobotanical assemblage from the town (*Hajnalová – Mihályová 1998*, 62). Of interest is the presence of grapevine (*Vitis vinifera*) in the 16th–17th century, which can ripen at this location today, although its quality is not particularly high. Due to the historical context of the wine trade in the region, which was disrupted by Ottoman expansion, the domestic source of the grapes could have been limited mainly to the area around Krupina or the Malé Karpaty (*Baďurík 1990*; *Miňo 2021*), and they might also have been imported in the form of raisins. On the other hand, the hops (*Humulus lupulus*) recorded in archaeobotanical samples could be related to beer brewing. Two preserved seeds of this taxon indicate that hops grew on the plot or on the adjacent estates. It is uncertain whether these hops were collected or intentionally cultivated. Naturally, wild hop plants grow in wet fen carrs as well as in river or stream bottoms (*Delyser – Kasper 1994*, 166). The first mentions of hop cultivation come from the year 736 AD in the area of Hallertau in Central Bavaria (*Bradáč 2008*, 38) and 768 AD in a letter of Pepin the Short. In the Slavic regions, written records mention hops from the 10th and 11th centuries (*Beranová 2005*, 122–124). and later archaeological records are also known (*Schneiderwinklová et al. 2008*, 191; *Široký et al. 2008*, 289; *Orna – Dudková 2018*). Wild hops were used in breweries alongside cultivated hops for a long time (*Beranová 2005*, 122–124). The final interpretation of this find is highly difficult because it cannot be determined whether it is a component of the natural vegetation growing on the plot or not. However, according to historical sources from 1556, the old brewery in the backyard of the main tract is documented (*Sura 1982*, 116) based on the brewing rights granted by Louis II of Hungary in 1524 for every house in Banská Bystrica (*Jurkovič 2005*, 184).

Environment and ecology

The finds of wild plants seem to be more interesting. They allow for a certain reconstruction of the species composition of the local flora and vegetation in the surrounding landscape (forests, meadows, fields) and provide insight into the climate of the time. Oak is currently found very sparsely around Banská Bystrica, i.e. in the northern part of Zvolenská kotlina Basin (e.g. *Šuvada 2023*, 266). It occurs commonly only further south of the Lukavica – Veľká Lúka – Badín line, due to local environmental influences and changes in management. The relatively high occurrence of oak in the samples may indicate its frequent presence as a result of specific landscape use in the Middle Ages, associated with targeted cultivation for economic timber and traditional management practices such as forest grazing, coppice management, or the collection of leaf litter. These practices helped keep the stands well-lit and increased the competitive abilities of *Quercus* species (*Roleček 2010*).

The presence of flax (*Linum usitatissimum*) testifies to the use of this crop. Weeds, such as *Agrostemma githago* recorded in the assemblage, commonly grew in the fields in the past. Nonetheless, this species is currently rare and listed as critically endangered (*Eliáš et al. 2015*) due to more efficient seed cleaning and the intensification of land use. This find is linked to crop use or farming, although cereal crops were not identified in the archaeobotanical record.

The other species composition shows a mixture of meadow plants (*Avena/Bromus*), weeds (*Agrostemma githago*, *Papaver rhoeas*, *Stachys arvensis*, *Solanum nigrum*, *Tanacetum vulgare*, *Capsella bursa-pastoris*), moisture-loving species (*Carex/Scirpus*, *Potentilla reptans*, *Ranunculus repens*, *Solanum dulcamara*), and species common in riparian vegetation (*Glechoma hederacea*, *Humulus lupulus*). The species typical for therophyte communities on cultivated soils and freshly disturbed ruderal habitats are the most common (*Barbarea vulgaris*, *Chenopodium album*, *Fallopia comvolvulus*, *Setaria viridis*, *Silene vulgaris*), which were naturally the most prevalent components of the medieval flora around dwellings and communities. From this list, it is possible to form an image of a medieval landscape near a river or stream, which consisted of a mosaic of the aforementioned types of habitats. This landscape does not differ much from some parts of today's landscape with low-intensity economic use and those not marked by collectivisation, such as the neighbourhood of the town of Krupina. Here, we find similar landscape elements and structures formed by natural, semi-natural and ruderal, and nitrophilous communities and their species in the vicinity of dwellings.

From the agricultural perspective, the historical cadastre of Banská Bystrica was not particularly valuable. Records from 1720 explain that two-thirds of the fields had poor yields, while the remaining one-third had only an average yield. As a result, the town greatly depended on grain imports (*Jurkovič 2005*, 205). However, the demand for protein-rich food by the mining communities, which were the backbone of the town's economy, boosted livestock production (e.g. *Skladaný 2010*, 43). The archaeobotanical finds from the cesspit, together with historical records and ecological research, provide clues about livestock management and the associated landscape use strategy. These findings suggest the existence of woodland pastures in the vicinity of the surveyed site and may indicate a pastoral strategy for raising domestic ruminants at least seasonally. Woodland pastures are known from written records in the eastern parts of the Štiavnické Vrchy Mountains, indirectly mentioned in 1367, and specifically described in the context of pig pastoralism in 1543 (*Maliniak 2019*, 73). Remains of woodland pastures in the Štiavnické Vrchy range, including rock-built enclosures for animals, were recorded in the Svätý Anton – Banský Studenec area. The pastures existed, according to remaining *Quercus* individuals, until the 19th century, but their origins are still unknown (*Miňo et al. 2020*, 54–55).

The distribution of wood pastures in Slovakia was analysed by *Wiezik et al.* (*2018*) based on the aerial map from 1950. One of the oldest recorded sites is Dobrá Niva – Gavurky, where the majority of standing trees are, on average, 250 years old, but individuals over 400 years are still present (*Fig. 13*). Thus, oak-based wood pasture seems to be an important part of the late medieval environment in the region. Not all of the woodland pastures proposed by *Wiezik et al.* (*2018*) need to be oak-based, as the discovery of pollarded *Fagus sp.* individuals in the woodland pasture of Uľanka suggests. However, today's typical *Quercus sp.* habitat appears to be constricted by mountain-affected climate, extending only about 10 km south of the historical cadastre of Bánská Bystrica. Yet, occasional enclaves of *Quercus sp.* relics along the right bank of the low terraces of the Hron River might indicate that this was not always the case. The written record from the early

Fig. 13. Example of woodland pasture relic at Dobrá Niva (photo by M. Miňo).

16th century (*Maliniak 2011*, 131) regarding *Quercus sp.* trees or growths, together with the preserved toponymy (after *ZBGIS*), indicates a more common distribution of *Quercus sp.* in the lower parts of the Banská Bystrica cadastre in the past (*Fig. 14*). The acorns from the current research were not dated, and their context extends from the 8th/9th century to the 16th (or possibly 19th?) centuries. The written records come mostly from the 16th century, as most of the earlier ones were lost to the fire in 1500.

Therefore, determining the time frame for the *Quercus sp.* occurrence in the Banská Bystrica area is challenging. However, there are hints of a longer tradition of pastoral land use in the surroundings, which may be connected to the sustenance of postglacial steppe relics through pastoral activities since the Neolithic, resulting in open park landscapes that survived at least until the 16th century AD. This correlates with the model by *Ložek* (*2011*, 71). The *Quercus sp.* and *Cornus mas* charcoal find from Netopierska Cave (4th/5th century AD), the 8th/9th-century and likely the 15th-century *Cornus mas* from the Banská Bystrica town centre[2] (*Hajnalová – Mihályová 1998*, 61–62) might suggest this scenario, as do the most recent yet unpublished finds of multiple sites with chipped stone industry

[2] The find is dated solely based on stratigraphy and pottery, but comes from a context that might be a 9th-century deposit disturbed by a 15th-century water pipe trench.

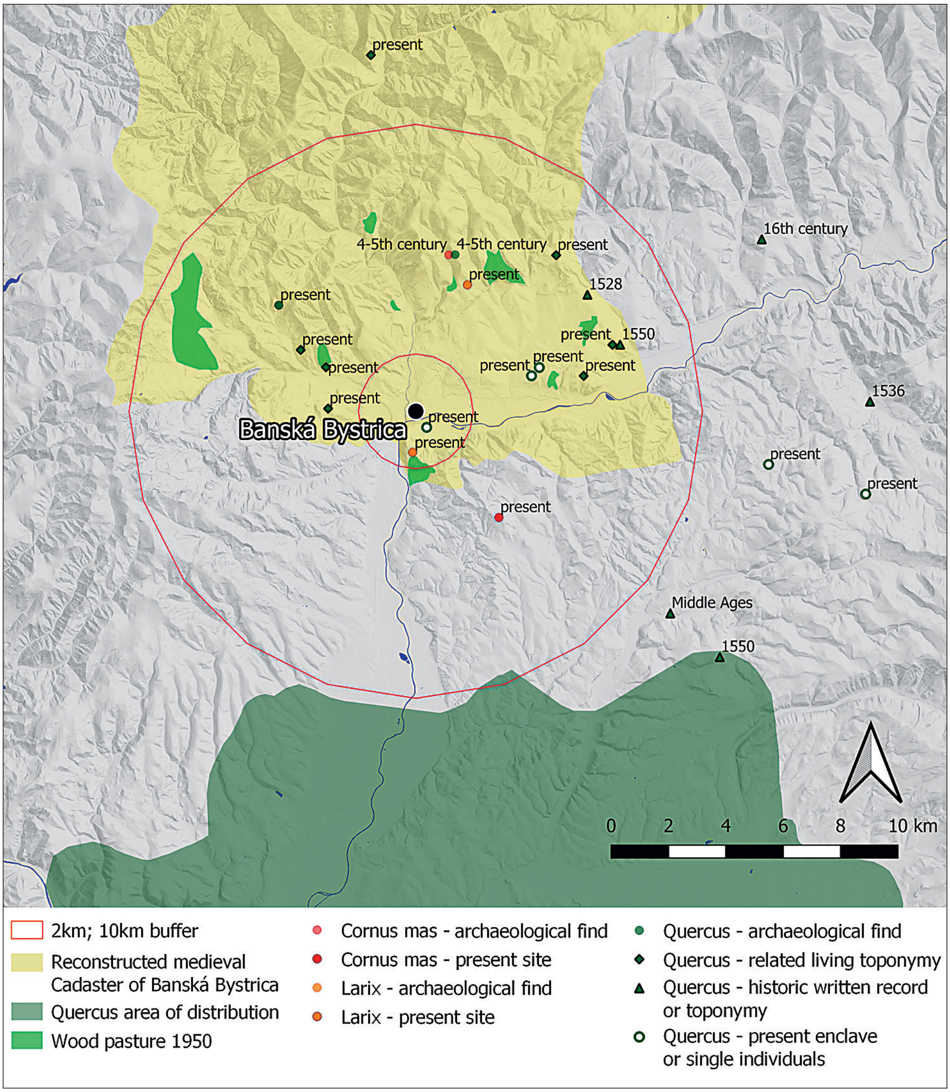

Fig. 14. Plan of past and recent oak (*Quercus*) growth distribution.

(presumably Copper Age and Bronze Age) in the region, correlating with recent or historical shepherds' cabin locations. One of them is located in the area of a historical *Quercus sp.* growth relict in Banská Bystrica – Senica. The presumably Late Iron Age shepherd gear from Selce might contribute to this, too. Notably, *Cornus mas* was present in all of the archaeobotanically examined deposits in Banská Bystrica, even though this taxon is very scarce at the location today. As *Swida sanguinea* may be common mainly in the highlands southeast of the town, the only site of *Cornus mas* was recorded on the southern slopes of Kozlinec Hill, some 10 km to the south of the town, but it is now typically found only as far south as the Krupina Plain.

Pastoral activities are also documented in 16th-century written records around the outskirts of the town (*Fig. 14*). The Castle Meadow extends from the town edge along the right bank terraces towards Senica and continues upriver as Chervartovsky Meadow (*Jurkovič 2005*, 206). Both properties contain *Quercus sp.* growth relics. The church-owned Bull Meadow was situated on the right bank of the Bystrica River, where today's Town Park is located, and the Upper Meadow was located in the backyards of Horná Street. Linked to the finds in the researched plot is the important Mühlstein estate, which was located on the left bank of the Hron River and consisted of a fishpond, a field, and a meadow (*Jurkovič 2005*, 205–207).

Importantly, young individuals of *Quercus sp.* were recently discovered at the edge of this property, appearing in the current natural succession, but they were not recorded here before. The estate lies in close proximity to the excavated site, and could thus be the source of acorns and twigs, as well as the hay containing meadow, wetland, and riparian taxa. The estate lies beneath Urpín Hill, which is the closest home of a *Larix* stand around Banská Bystrica and includes rocky stands or coulees that might be the original stand of the recorded find based on its overall properties. One of past woodland pastures proposed by *Wiezik et al.* (*2018*) is located in this area as the Urpín Wood Steppe protected natural reserve. It is important to note that *Quercus sp.* woods, exploited by pollarding the trees in wooded pastures, might have been a relevant source of charcoal for local silver and copper smelting facilities. These facilities were not only an important part of the town's economy but also influenced the ecology. A pertinent example is the historical record from Matthias Bel, who described the malevolent winds carrying copper fumes from Banská Bystrica to the Lower Manor in the neighbouring town of Radvaň (*Bel 2017*, 314–315).

According to the results of our ICP-MS and ICP-OES analyses, the contents of selected metals relatively correlate with average values of non-contaminated soils. Since Banská Bystrica was affected by the copper mining and processing, the presence of lead, which was used for separating silver from copper, may be related to smelting activity (*Irabien et al. 2012*). The results of the presented samples should be compared with the range of elements found in soils from the wider environment of the studied region. Additionally, various influences of the geological substrate and supporting evidence of the structural behaviour at the site (from excavation, geophysics, surface survey, or even field names) should be compared accordingly. This should lead to meaningful conclusions, because as the review by *Bintliff* and *Degryse* (*2022*) shows, elementary analysis alone can lead to misleading results. However, if more analysed samples yield comparable results, this would confirm flue ash contamination of the soil in the inhabited part of the town prior the great fire in the year 1500.

Conclusion

The paper presents the possibilities for the reconstruction of original situations based on traditional documentation techniques such as photography and drawing. The method described in this paper proved feasible for recreating a three-dimensional image of the archaeological situation based on a small number of photographs, using depth maps as the main tool.

The other line of results consists of interdisciplinary findings that provide a comprehensive view of life in Banská Bystrica. Specifically, it offers information on the economy and land use of the inhabitants of two town plots, where the town hall was later built. The archaeological and historical records suggest that the economy was primarily focused on livestock breeding, for both dairy and meat production. This significantly affected a large part of the landscape around the Hron River, as open land had to be maintained for both summer pasture and hay production. The livestock-focused economy was particularly important in an agriculturally unfavourable environment for basic sustenance, not only for the citizens but also for the miners working in the mining fields deeper in the mountains. This land use strategy helped to preserve ancient open ecological environments, which disappeared due to collectivisation in the 20th century.

We also addressed the issue of dating. Cesspit O10 is perhaps the most precisely dated archaeological feature in the region, since we employed multiple exact dates provided by radiocarbon dating and dendrochronology. However, the results are confusing. Although the pottery from this pit is, except for a single older pot, uniformly dated to a short period and seems to provide a clear dating, the exact dates range across a whole millennium, which is a very broad range in the context of historical archaeology. On one hand, the dates relate to a prolonged continuity of settlement, even to the continuity of the plot and its function. On the other hand, it raises a warning about the constraints of possibilities for standard archaeological dating based on typology. All of the organic finds would be attributed to the same period as the pottery, which would be correct when considering the process of deposition, but not in terms of their origin. Thus, with the typological method, the sense of the prolonged life of some artefacts and its implications for the overall interpretation would be much more constrained. Another important outcome is the realisation that omitting the sampling of deposits while conducting rescue archaeology might result in the loss of information that is often more crucial than that retrieved from material culture. This is important because most sites where rescue archaeology applies are condemned to physical destruction.

This study was supported by the OP RDE, MEYS, under the project 'Ultra-trace isotope research in social and environmental studies using accelerator mass spectrometry', Reg. No. CZ.02.1.01/0.0/0.0/16_019/0000728, and by the project VEGA 2/0097/22 – Understanding of complex biodiversity response to forest management: integration of a multi-taxa approach in ecosystem function assessments – DECISION.

References

Adams, B. J. – Crabtree, P. J. 2008: Comparative skeletal anatomy: a photographic atlas for medical examiners, coroners, forensic anthropologists, and archaeologists. Totowa – New Jersey: Humana Press.

Atta, N. N. – El-Baz, A. A. – Said, N. – Abdel Daiem, M. M. 2016: Anaerobic Co-Digestion of Wastewater Activated Sludge and Rice Straw in Batch and Semi Continuous Modes. Journals of Fundamentals of Renewable Energy and Applications 6, 1–7. https://doi.org/10.4172/2090-4541.1000204

Baďurík, J. 1990: Malokarpatské vinohradníctvo v 16. storočí. Bratislava: Commenius University.

Bain, A. – King, G. 2011: Asylum for Wayward Immigrants: Historic Ports and Colonial Settlements in Northeast North America. Journal of the North Atlantic Special Volume 1: Archaeologies of the Early Modern North Atlantic, 109–124.

Baláž, J. 2002: Banská Bystrica v premenách času. Banská Bystrica: vydavateľstvo BAJA.

Behrensmeyer, A. K. 1978: Taphonomic and Ecologic Information from Bone Weathering. Paleobiology 4, 150–162.
Bel, M. 2017: Zvolenská stolica. Čadca: Kysucké múzeum v Čadci – Stredoslovenské múzeum.
Beranová, M. 2005: Jídlo a pití v pravěku a středověku. Praha: Academia.
Bintliff, J. – Degryse, P. 2022: A review of soil geochemistry in archaeology. Journal of Archaeological Science: Report 43, 103419. https://doi.org/10.1016/j.jasrep.2022.103419
Bocheński, Z. M. – Tomek, T. 2009a: A key for the identification of domestic bird bones in Europe: Galliformes and Columbiformes. Kraków: Institute of Systematics and Evolution of Animals, Polish Academy of Sciences.
Bocheński, Z. M. – Tomek, T. 2009b: A key for the identification of domestic bird bones in Europe: Preliminary determination. Kraków: Institute of Systematics and Evolution of Animals, Polish Academy of Sciences.
Boessneck, J. 1969: Osteological differences between sheep (Ovis aries Linné) and goat (Capra hircus Linné). In: D. R. Brothwell – E. S. Higgs (eds.), Science in archaeology: A survey of progress and research. London: Thames and Hudson, 311–358.
Boriová, S. 2019: Zvieratá od šibeníc. Svedectvo kostí. In: J. Unger (ed.), Jihomorovské šibenice v časném novověku (16.–18. stol.). Brno: Masarykova Univerzita, 23–128.
Bradáč, V. 2008: Chmelařství a pivovarnictví na Žatecku. Louny: Digon.
Bronk Ramsey, C. 2009: Bayesian analysis of radiocarbon dates. Radiocarbon 51, 337–360. https://doi.org/10.2458/azu_js_rc.51.3494
Bronk Ramsey, C. 2017: Methods for Summarizing Radiocarbon Datasets. Radiocarbon 59, 1809–1833. https://doi.org/10.1017/RDC.2017.108
Bronk Ramsey, C. – Van Der Plicht, J. – Weninger, B. 2001: 'Wiggle matching' radiocarbon dates. Radiocarbon 43, 381–389. https://doi.org/10.1017/S0033822200038248
De Cupere, B. – Speleers, L. – Mitchell, P. – Degraeve, A. – Meganck, M. – Bennion-Pedley, E. – Jones, A. – Ledger, M. – Deforce, K. 2022: A Multidisciplinary Analysis of Cesspits from Late Medieval and Post-Medieval Brussels, Belgium: Diet and Health in the Fourteenth to Seventeenth Centuries. International Journal of Historical Archaeology 26, 531–572. https://doi.org/10.1007/s10761-021-00613-8
Delyser, D. Y. – Kasper, W. J. 1994: Hopped Beer: The Case for Cultivation. Economic Botany 48, 166–170.
von den Driesch, A. 1976: Das Vermessen von Tierknochen aus vor- und frühgeschichtlichen Siedlungen. München: Tierarztlichen Fakultät der Ludwig-Maximilians-Universität.
Eliáš, P. jun. – Dítě, D. – Kliment, J. – Hrivnák, R. – Feráková, V. 2015: Red list of fern and flowering plants of Slovakia, 5th edition (October 2014). Biologia 70, 218–228. https://doi.org/10.1515/biolog-2015-0018
France, D. L. 2009: Human and nonhuman bone identification: a color atlas. Boca Raton: CRC Press.
Glasgow: Archaeology Consortium, TL TP, University of Glasgow.
Grant, A. 1982: The use of tooth wear as a guide to the age of domestic ungulates. In: B. Wilson – C. Grigson – S. Payne (eds.), Ageing and sexing animal bones from archaeological sites. Oxford: BAR Publishing, 91–108.
Gupta, S. K. – Polach, H. A. 1985: Radiocarbon dating practises at ANU. Canberra: ANU.
Güntherová, A. et al. 1967: Súpis pamiatok na Slovensku, A–J. Bratislava: Obzor.
Hajnalová, E. – Mihályová, J. 1998: Archeobotanické nálezy v roku 1996. Archeologické výskumy a nálezy na Slovensku v roku 1996, 61–62.
Halstead, P. – Collins, P. 1995: Sheffield animal bone tutorial: Taxonomic identification of the principal limb bones of common European farmyard animals and deer: a multimedia tutorial. Halstead, P. – Collins, P. – Isaakidou, V. 2002: Sorting the Sheep from the Goats: Morphological Distinctions between the Mandibles and Mandibular Teeth of Adult Ovis and Capra. Journal of Archaeological Science 29, 545–553. https://doi.org/10.1006/jasc.2001.0777
Harris, E. C. 1989: Principles of archaeological stratigraphy. London: Academic Press.
Hillson, S. 2005: Teeth. Cambridge: Cambridge University Press.
Holliday, V. – Gartner, W. 2007: Methods of soil P analysis in archaeology. Journal of Archaeological Science 34, 301–333. https://doi.org/10.1016/j.jas.2006.05.004
Hoššo, J. 1983: Prehľad vývoja stredovekej keramiky na Slovensku. Archaeologia historica 8(1), 215–229.
Hoššo, J. 1996: O takzvaných bratislavských pohároch (príspevok k poznaniu keramických gotických pohárov). Zborník Slovenského národného múzea XC – Archeológia 6, 197–204.
Hoššo, J. 2007: Komplex drevozemných stavieb a objektov z neskorého stredoveku v Trnave na Hviezdoslavovej ul. Pamiatky Trnavy a Trnavského kraja 11, 3–10.

Hrašková, E. et al. 2009: Dostavba a prístavba štátnej opery, Banská Bystrica. Výskumná dokumentácia z archeologického výskumu. Banská Bystrica: Ithaka BB and Krajský pamiatkový úrad Banská Bystrica.
Irabien, M. J. – Cearreta, A. – Urteaga, M. 2012: Historical signature of Roman mining activities in the Bidasoa estuary (Basque Country, northern Spain): an integrated micropalaeontological, geochemical and archaeological approach. Journal of Archaeological Science 39, 2361–2370. https://doi.org/10.1016/j.jas.2012.02.023
Jones, M. K. 1991: Sampling in palaeoethnobotany. In: W. van Zeist – K. Wasylikowa – K. E. Behre (eds.), Progress in the Old World Palaeoehtnobotany. Rotterdamm: Balkema, 53–62.
Jull, A. J. T. – Burr, G. S. – Beck, J. W. – Hodgins, G. W. L. – Biddulph, D. L. – Gann, J. – Hatheway, A. L. – Lange, T. E. – Lifton, N. A. 2006: Application of accelerator mass spectrometry to environmental and paleoclimate studies at the University of Arizona. Radioactivity in the Environment 8, 3–23. https://doi.org/10.1016/S1569-4860(05)08001-0
Jurkovič, E. 2005: Dejiny kráľovského mesta Banská Bystrica. Banská Bystrica: Pribicer.
Kolda, J. 1951: Osteologický atlas. Praha: Zdravotnické nakladatelství.
Kučera, J. – Maxeiner, S. – Müller, A. – Němec, M. – John, J. et al. 2022: A new AMS facility MILEA at the Nuclear Physics Institute in Řež, Czech Republic. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms 527, 39–33. https://doi.org/10.1016/j.nimb.2022.07.012
Kvietok, M. 2016: Polyfunkčný dom Horná čp. 2–4. Výskumná dokumentácia z archeologického výskumu. Banská Bystrica: Stredoslovenské múzeum.
Kvietok, M. – Mácelová, M. 2013: Krása kachlíc. Katalóg výstavy. Banská Bystrica: Stredoslovenské múzeum.
Lacko, M. 2024: Výroba zelenej farby v Uhorsku do konca 18. storočia. Historica revue pro historii a příbuzné vědy 2024/1, 17–41.
Ložek, V. 2011: Zrcadlo minulosti. Praha: Dokořán.
Mácelová, M. 1998: Výskum na námestí SNP v Banskej Bystrici. Archeologické výskumy a nálezy na Slovensku v roku 1996, 112–113.
Mácelová, M. 2005: Ikonografia gotických kachlíc z banskobystrickej radnice. In: J. Chovanec (ed.), Gotické a renesančné kachlice v Karpatoch. Trebišov: Arx Paris, 205–216.
Mácelová, M. 2013: Slovania vo Zvolenskej kotline. Kraków: Wydawnictvo Towarzystwa Słowaków w Polsce.
Maliniak, P. 2011: Človek a krajina Zvolenskej kotliny v stredoveku. Banská Bystrica: Univerzita Mateja Bela.
Maliniak, P. 2019: Čabradské panstvo v stredoveku. Banská Bystrica: Belianum.
Marhold, K. – Hindák, F. (eds.) 1998: Zoznam vyšších a nižších rastlín Slovenska. Checklist of non-vascular and vascular plants of Slovakia. Bratislava: VEDA, vydavateľstvo Slovenskej akadémie vied.
Miňo, M. 2021: Renaissance-Era Rock Cut Cellars in the Economy of a Fortified City in the War Frontier between Two Civilizations. In: C. Sciuto – A. Lamesa – K. Whitaker – A. Yamaç (eds.), Carved in stone. Oxford: BAR, 91–102.
Miňo, M. – Brezňanová, G. – Fratričová, M. 2008: Banská Bystrica – radnica. Dokumentácia náhodného archeologického nálezu. Banská Bystrica: Krajský pamiatkový úrad Banská Bystrica.
Miňo, M. – Fratričová, M. – Rusko, Z. 2020: Výsledky krajinno-archeologického plošného nedeštruktívneho prieskumu v jadrovom území lokality UNESCO Banská Štiavnica a technické pamiatky okolia. Argenti Fodina 2020, 46–58.
Orna, J. – Dudková, V. 2018: Možnosti archeologie pro poznání produkce potravin v pozdně středověké Plzni. Archaeologia historica 43(2), 335–351. https://doi.org/10.5817/AH2018-2-1
Orsovszki, G. – Rinyu, L. 2015: Flame-sealed tube graphitization using zinc as the sole reduction agent: precision improvement of Environ MICADAS 14C measurements on graphite targets. Radiocarbon 57, 979–990. https://doi.org/10.2458/azu_rc.57.18193
Payne, S. 1973: Kill-off patterns in sheep and goats: the mandibles from Asvan Kale. Anatolian Studies 23, 281–303. https://doi.org/10.2307/3642547
Payne, S. 1987: Reference codes from wear states in the mandibular cheek teeth of sheep and goats. Journal of Archaeological Science 14, 609–614. https://doi.org/10.1016/0305-4403(87)90079-3
Pearson, G. W. 1986: Precise calendrical dating of known growth-period samples using a “curve-fitting” technique. Radiocarbon 28, 292–299. https://doi.org/10.1017/S0033822200007396
Popesko, P. 2007: Atlas topografickej anatómie hospodárskych zvierat. Bratislava: Príroda.
Reimer, P. – Austin, W. – Bard, E. – Bayliss, A. – Blackwell, P. et al. 2020: The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62, 725–757. https://doi.org/10.1017/RDC.2020.41

Reitz, E. J. – Wing, E. S. 2008: Zooarchaeology. Cambridge – New York: Cambridge University Press.
Roleček, J. 2010: Fenomén subkontinentálních doubrav: diverzita, dynamika a historie jednoho neobyčejného společenstva. Živa 6, 256–258.
Ruttkay, M. 1995: Príspevok k poznaniu stredovekej keramiky na juhozápadnom Slovensku. Archaeologia historica 20(1), 563–583.
Schlezinger, D. R. – Howes, B. L. 2000: Organic phosphorus and elemental ratios as indicator of prehistoric human occupation. Journal of Archaeological Science 27, 479–492. https://doi.org/10.1006/jasc.1999.0464
Schmid, E. 1972: Atlas of animal bones: For prehistorians, archaeologists and Quaternary geologists. Knochenatlas. Für Prähistoriker, Archäologen und Quartärgeologen. Amsterdam – New York: Elsevier Pub. Co.
Schneider, R. J. – McNihol, A. P. – Nadeu, M. J. – Reden, K. F. 1995: Measurements of the Oxalic Acid II/Oxalic Acid I Ratio as a Quality Control Parameter at NOSAMS. Radiocarbon 37, 693–696. https://doi.org/10.1017/S0033822200031210
Schneiderwinklová, P. – Kostrouch, F. – Sůvová, Z. – Kočár, P. – Kočárová, R. – Kyncl, T. – Klozar, A. – Petr, L. 2008: Raně novověká studna z Plzně, Perlové ulice – výpověď archeologických a environmentálních pramenů. In: V. Hašek – R. Nekuda – M. Ruttkay (eds.), Ve službách archeologie VIII/2. Brno, Nitra: Muzejní a vlastivědná společnost: Geodrill, Archeologický ústav, Slovenská akadémia vied, 175–196.
Shipman, P. – Foster, G. – Shoeninger, M. 1984: Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. Journal of Archaeological Science 11, 307–325. https://doi.org/10.1016/0305-4403(84)90013-X
Skladaný, M. 2010: Banská Bystrica. In: M. Štefánik – J. Lukačka (eds.), Lexikón stredovekých miest na Slovensku. Bratislava: Historický ústav SAV, 29–51.
Smith, D. 2013: Defining an indicator package to allow identification of 'cesspits' in the archaeological record. Journal of Archaeological Science 40, 526–543. https://doi.org/10.1016/j.jas.2012.06.014
Smith, D. 2020: Pondering Privies: Construction, Use, Reuse,and Other Speculations About Cesspits in the Archaeological Record. Journal of Archaeological Method and Theory 28, 446–469. https://doi.org/10.1007/s10816-020-09459-6
Staníková, E. 1990: Banská Bystrica – Námestie SNP č. 1 meštiansky dom. Umelecko – historický a architektonický výskum. Banská Bystrica: PÚK Bratislava, stredisko Banská Bystrica.
Sura, M. 1982: Banská Bystrica. Pamiatková rezervácia. Bratislava: Tatran.
Sura, M. – Kasper, J. – Škandík, I. 1996: Banská Bystrica – radnica. Námestie SNP č. 1. Umelecko – historický, architektonický a reštaurátorský prieskum. Bratislava – Banská Bystrica: Národné pamiatkové a krajinárske centrum Bratislava – Národné stredisko pre reštaurovanie Banská Bystrica.
Šimkovic, M. – Žuffová, J. 2021: Banská Bystrica – dom meštiansky tzv. Thurzov dom, Námestie SNP 4. (č. ÚZPF 2458/1) – architektonicko-historický a umelecko-historický výskum interiéru 1. 2. a 3. NP. Zvolen: Michal Šimkovic.
Široký, R. – Kočár, P. – Hlaváč, J. – Kaštovská, K. – Kostrouch, F. – Kyncl, J. – Militký, J. – Pokorný, P. – Postránecká, K. – Schneiderwinklová, P. 2008: Příkop středověkého opevnění města Plzně: archeologický a environmentální výzkum v prostoru zaniklé Pražské brány. Forum urbes medii aevi – Městské fortifikace ve vrcholně středověkých zeměpanských městech střední Evropy 5, 272–311.
Šuvada, R. (ed.) 2023: Katalóg biotopov Slovenska. Banská Bystrica: Štátna ochrana prírody.
Teichert, M. 1969: Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei vor- und frühgeschichtlichen Schweinen. Kühn-Archiv 83, 237–292.
Terry, R. E. – Hardin, P. J. – Houston, S. D. – Nelson, S. D. – Jackson, M. W. – Carr, J. – Parnell, J. 2000: Quantitative phosphorus measurement: A Field test procedure for archaeological site analysis at Piedras Negras, Guatemala. Geoarchaeology: An International Journal 15, 151–166. https://doi.org/10.1002/(SICI)1520-6548(200002)15:2<151::AID-GEA3>3.0.CO;2-T
Thurzo, M. – Beňuš, R. 2005: Základy tafonómie hominidov a iných stavovcov. Bratislava: Univerzita Komenského.
Ušiak, P. 1997: Výskumná správa z archeologického výskumu Banská Bystrica – mestský hrad, časť barbakan, Banská Bystrica: Univerzita Mateja Bela, archív KPÚ Banská Bystrica sign. T 714, Banská Bystrica.
Ušiak, P. 1999: Výskumná správa z archeologického výskumu Banská Bystrica – mestský hrad, časť barbakan, Banská Bystrica: Univerzita Mateja Bela, archív KPÚ Banská Bystrica sign. T 715, Banská Bystrica.
Wiezik, M. – Lepeška, T. – Gallay, I. – Modranský, J. – Olah, B. – Wieziková, A. 2018: Wood pastures in Central Slovakia – collapse of a traditional land use form. Acta Scientarum Polonorum. Formatio Cirumiectus 17, 109–119. https://doi.org/10.15576/ASP.FC/2018.17.4.109

Zachar, J. – Mácelová, M. 2008: Výskumná dokumentácia z archeologického výskumu, I. etapa, Polyfunkčný dom, horná 2–4, Banská Bystrica. Banská Bystrica: Stredoslovenské múzeum.

ZBGIS: Mapový klient ZBGIS. Available at: https://zbgis.skgeodesy.sk/mkzbgis/sk/kataster [accessed 01-02-2023].

Zoetis, T. – Tassinari, M. S. – Bagi, C. – Walthall, K. – Hurtt, M. E. 2003: Species comparison of postnatal bone growth and development. Birth Defects Research (Part B): Developmental and Reproductive Toxicology 68, 86–110. https://doi.org/10.1002/bdrb.10012

Žuffová, J. 2009: Doplňujúce poznatky k typu primárneho murovaného meštianskeho domu Trnavy. Pamiatky Tranavy a Trnavskéhoj kraja 12, 47–66.

MARTIN MIŇO, Regional Monuments Board of Banská Bystrica, Lazovná 239/8, SK-974 01 Banská Bystrica, Slovakia; martin.mino@pamiatky.gov.sk

BARBORA STYKOVÁ, Nuclear Physics Institute of the Czech Academy of Sciences, Na Truhlářce 39/64, CZ-180 86 Praha 8, Czech Republic; barbora.stykova@gmail.com

IVAN JAROLÍMEK, Department of Biodiversity and Ecology, Institute of Botany, Plant Science and Biodiversity Center, Slovak Academy of Sciences, Dúbravská cesta 9, SK-845 23 Bratislava, Slovakia ivan.jarolimek@savba.sk

JOZEF ŠIBÍK, Department of Biodiversity and Ecology, Institute of Botany, Plant Science and Biodiversity Center, Slovak Academy of Sciences, Dúbravská cesta 9, SK-845 23 Bratislava, Slovakia; jozef.sibik@savba.sk

MÁRIA ŠIBÍKOVÁ, Department of Biodiversity and Ecology, Institute of Botany, Plant Science and Biodiversity Center, Slovak Academy of Sciences, Dúbravská cesta 9, SK-845 23 Bratislava, Slovakia maria.sibikova@savba.sk

MOJMÍR CHOMA, ADendro, A. Dubčeka 14, SK-921 01 Piešťany, Slovakia; mojmirch@gmail.com

KATARÍNA ŠIMUNKOVÁ, Department of Archaeology, Constantine the Philosopher University in Nitra, Hodžova 1, SK-949 01 Nitra, Slovakia; ksimunkova@ukf.sk

MICHAELA LÁTKOVÁ, Institute of Archaeology Czech Academy of Science, Brno – Research base Mikulčice, Mikulčice 736, CZ-696 19 Mikulčice, Czech Republic; latkova@arub.cz

IVO SVĚTLÍK, Nuclear Physics Institute of the Czech Academy of Sciences, Na Truhlářce 39/64, CZ-180 86 Praha 8, Czech Republic; svetlik@ujf.cas.cz

KATEŘINA PACHNEROVÁ BRABCOVÁ, Nuclear Physics Institute of the Czech Academy of Sciences, Na Truhlářce 39/64, CZ-180 86 Praha 8, Czech Republic; brabcova@ujf.cas.cz

MARKÉTA PETROVÁ, Nuclear Physics Institute of the Czech Academy of Sciences, Na Truhlářce 39/64, CZ-180 86 PRAHA 8, Czech Republic; Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, CZ-115 19 Praha, Czech Republic; petrova@ujf.cas.cz

PETER ĎURICA, archaeologist of the municipality of Letanovce, Slovakia; peter.durica@letanovce.sk

PETER BARTA, Bratislava City Museum, Radničná 1, SK-815 18 Bratislava, Slovakia; Nuclear Physics Institute of the Czech Academy of Sciences, Na Truhlarce 39/64, CZ-180 86 Praha 8, Czech Republic peter.barta@mmb.sk

PAVOL MIDULA, Faculty of Environment, Jan Evangelista Purkyně University in Ústí nad Labem, Pasteurova 1, CZ-400 01 Ústí nad Labem, Czech Republic; pavol.midula@gmail.com

JANKA ŠEVČÍKOVÁ, Faculty of Natural Sciences, Matej Bel University in Banská Bystrica, Tajovského 40, SK-974 01 Banská Bystrica, Slovakia; janka.sevcikova@umb.sk